POWER PLANT ENGINEERING

GENERATION - TRANSMISSION - DISTRIBUTION - UTILIZATION

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Photo, Courtesy, Westinghouse

ARC SNUFFER

THE OPERATING REQUIREMENTS of present day electrical equipment are unusually severe but the electrical engineer by virtue of his knowledge of fundamental principles and his skill in applying them manages to meet these requirements, however rigid they may be. In the case of the 287,500 v. Boulder Dam circuit breakers, specifications demanded an interrupting capacity of a short circuit current equivalent to 2,500,000 kv-a. at full line voltage in a total elapsed time of less than 3 cycles or 0.05 sec. Even in the best circuit breaker circles this was a large order. Yet these demands were met successfully by different manufacturers in different ways. In the photograph above is shown an unusual view of one of the De-ion grid interrupters for one of the Westinghouse breakers for Boulder Dam as a skilled worker applies a few finishing touches in the factory. This grid assembly constitutes half the interrupters in a single pole unit of a 3 phase breaker. Based on Dr. Slepian's fundamental studies of the arc and the mechanism of deionization, these breakers on test have proved their ability to open the maximum short circuit currents of the Boulder Dam line in less than the required 3 cycles.

WITH THE EDITORS

Your Government

ISSUES to be voted upon at the coming election, as to policies of government and the men to carry them out, are the most important of any put before the people of this country since 1860. It is the kind of government under which you will live, Your Government, that is to be decided. Each one has full opportunity to become informed on the issues to be decided, to make up his mind what he wants and to use his efforts to have selected those policies and officials which he prefers. It is most important that the election be the expression of the will of *all* the people. Unless each voter votes and does his best to get others to vote, he has no reason for grumbling if things do not go to his liking in the affairs of town, city, county, state or nation. Its your job as well as your privilege to register to vote and to urge all others with whom you come in contact to do likewise.

If Repairs Are Necessary

ON EVERY HAND, the indications are that the installed power plant equipment in the country will be working to the limit of its capacity with demand for more power as the autumn load begins to set in. The utilities have already reached an all time peak output this year and manufacturers of many lines of power equipment are being hard pressed by customers for early delivery. Factories and other power users who are finding difficulty in securing additional needs from utility plants are reported to be ordering Diesel engines and engineers everywhere are dusting off old machinery and putting it in shape for the coming power demand.

During the recent years of light load, the practice of "borrowing" parts from the unused equipment in order to keep the plant running became a chronic habit in many plants and the uncomfortable situation of having a spare unit in the plant that cannot be used is now giving a headache to many engineers. To repair and recondition obsolete equipment seems like the height of folly, yet just such a procedure is being forced upon many plants that have not made proper provision for rapid expansion and must now resort to expedients that are far from satisfactory and will prove extremely expensive as increasing loads and continuous operation place heavy strains on old equipment.

In cases where delivery of important new equipment cannot be made in time to meet the demand for increased loads, a complete reconditioning of the equipment should be undertaken rather than to attempt patch-work repairs made by a power plant staff inadequately equipped with machine tools and inexperienced in factory methods. This reconditioning should be done by a representative of the manufacturer or at least under his direction, his familiarity with the latest equipment may suggest slight changes that would to some extent modernize the equipment.

In the automobile field, manufacturers have found it profitable to supply the higher priced old cars with reconditioned and modernized engines at a cost that makes the transaction profitable to both manufacturer and car owner. The standardization that has been carried on for years in power equipment makes an adaptation of this practice deserving of consideration where manufacturers are pressed with orders. Certainly customers, who are ready to order new units but are forced to delay due to the overworked condition of the factory, are entitled to the council of the manufacturer in the immediate solution of their equipment problems. A manufacturer may not consider himself in the repair business, nevertheless his organization should be best equipped to service or repair its own products and the profits should be as inviting to the manufacturer as to any other company the plant may secure to do the work.

Superposition "On the Make"

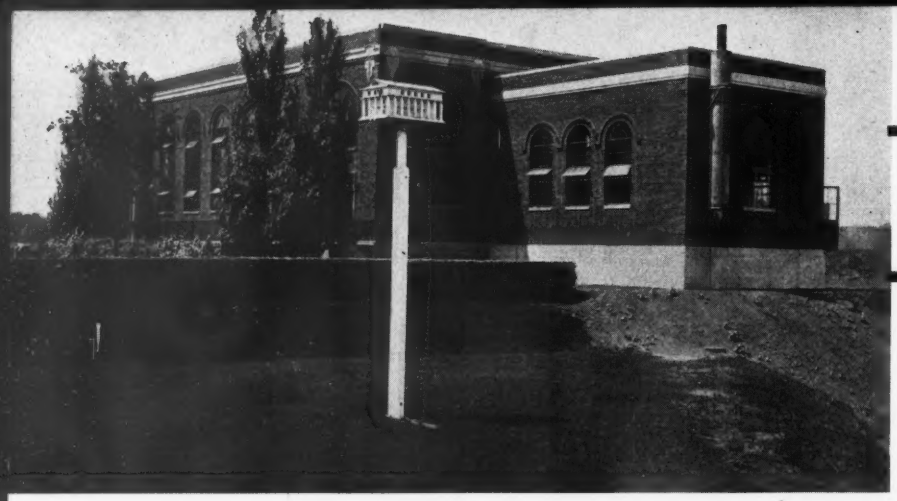
FEW IDEAS in power plant practice in recent years have met with such whole-hearted acceptance as has that of the superposition plant. An analysis of central station turbines purchased during the first five months of 1936 discloses that of eleven turbines bought totalling 275,000 kw., only four with a combined rating of 67,500 kw. are condensing units. Of the other seven, six were 1200 lb. superposition turbines and the seventh a 625 lb. superposition unit of 12,500 kw. rating. Over 75 per cent of the purchased capacity was in superposition turbines.

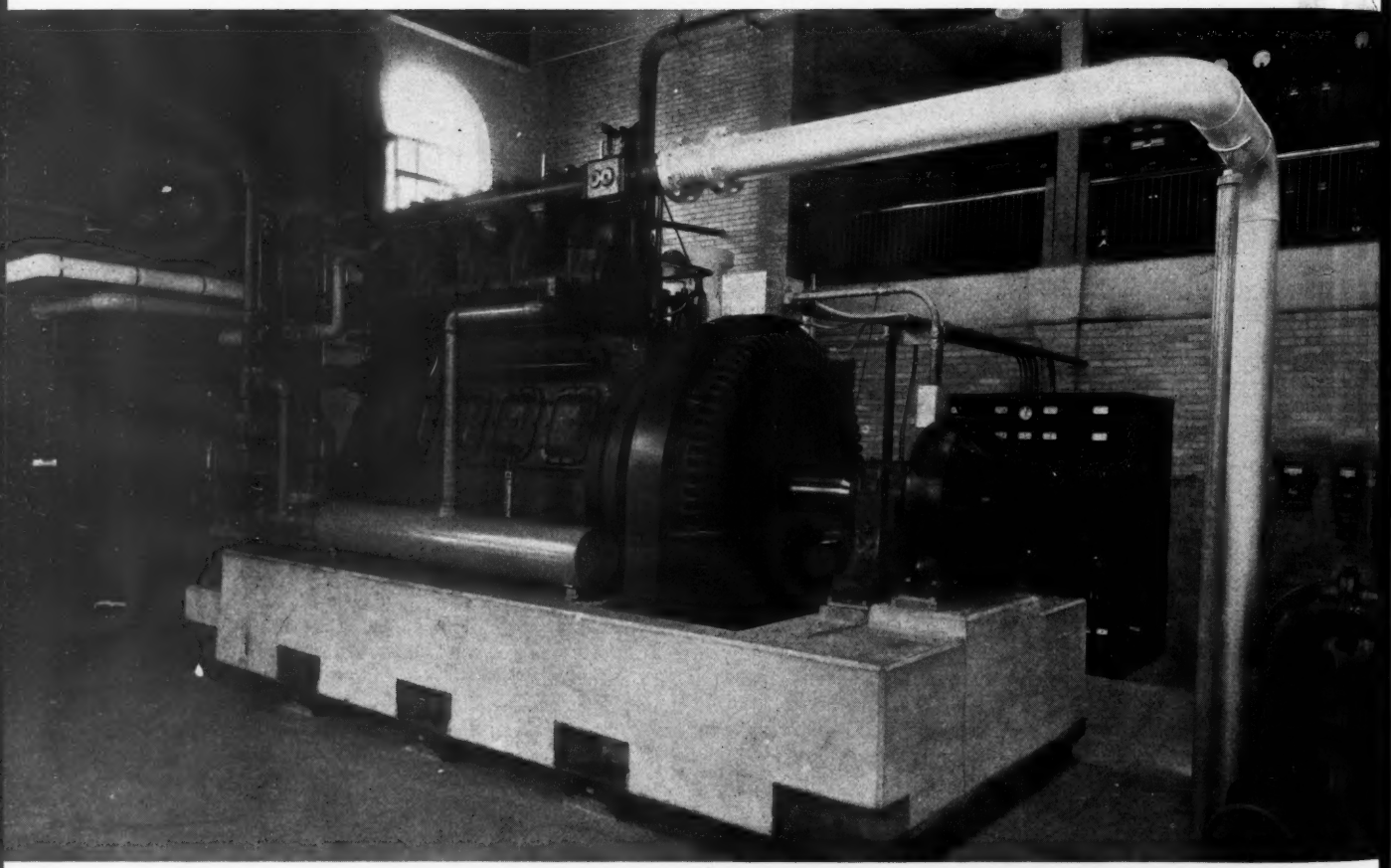
This general acceptance of the superposition idea need not surprise us. It would have been more surprising had it not been accepted, for the superposition principle is fundamentally sound and especially at the present time offers many advantages over alternative arrangements for increasing station capacity. Not only does it provide a plant that can develop power at a fuel cost comparable to that of the best condensing plants but it uses the obsolescent, standby unit and makes it an integral part of an economical, modern and valuable installation, adding decades to its useful life and appreciating greatly its value.

Much of the power plant equipment in use today was installed within the past twenty years. This is not a long time in terms of the life of plant equipment and nearly all of this equipment is in perfect operating condition. In point of thermal efficiency, however, these assemblies do not compare with more recent equipment making use of the high pressure, high temperature heat cycle. As a consequence this equipment has been somewhat of a problem to the power plant owners. It was too good to discard yet not good enough, thermally, to run.

The superposition plant solves this problem, simply and effectively. By merely adding high pressure boilers and high pressure turbines and arranging these turbines to exhaust into the existing low pressure system, the thermal economy of the entire old plant is raised to a point where it can successfully compete with modern high pressure equipment. No wonder the idea took hold.

Peoria





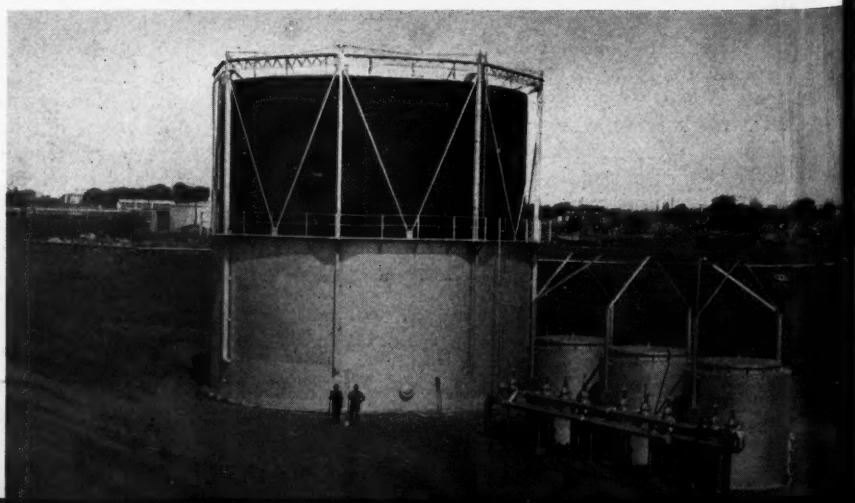


Fig. 1. (Upper left) Exterior view of plant showing extension for blower unit. Note silencer on outside of building

Fig. 2. (Center) The generating unit. Note vibro-damper supports

Fig. 3. (Right) The 50,000 cu. ft. gas holder and purifiers

Plant Generates Electric Power *from* Sewage

New Power Generating Installation Utilizes Gases Generated by Decomposition of Sewage Directly in Gas Engines. Preliminary Estimates Indicate an Annual Saving of Over $20,000

THE EVILS OF SEWER gas are legion; they need no description nor elaboration for they have long been known to everybody especially housewives to whom they have been responsible for many hurry-up calls for plumbers but to be able to say something good about sewer gas would be something, it will be admitted, decidedly unusual. Yet, that is exactly what we expect to do in this article for down in Peoria, Illinois, they have at last found use for this evil smelling, unhealthy by-product of domestic and industrial waste.

This quite astonishing feat has been accomplished at the new sewage disposal plant of the Greater Peoria Sanitary and Sewage Disposal District where sewer gas, or more properly, gas generated as a result of decomposition of sewage by special processes is used to drive gas engines which in turn produce electric power.

Estimated Savings Over $20,000 a Year

So effective is this process that the Peoria Sanitary District expects to save an estimated $20,000 annually by reducing the power bill. The installation of the equipment necessary to convert the hitherto wasted gas into power required an investment of approximately $100,000, 25 per cent of which was a grant from the federal government through the P.W.A. The project, therefore, is expected to pay for itself, so far as the municipality is concerned, in something less than 4 yr.

The recovery of valuable gas from the digestion tanks of sewage treatment systems wherein the sewage is treated by bacterial processes, is comparatively new, although the oldest of such gas power plants is some 30 yr. of age. The first place gas from decomposing waste matter was used for power was in Bombay, India. The largest installation of this kind is at Birmingham, England. There are numerous large plants in England and Central Europe that make use of such gas for heating as well as for generating power, but in this country such installations are few. A new plant of this kind was recently constructed at Durham, North Carolina, also with a grant from the Public Works Administration. The Sanitary District of Springfield (Illinois) has very profitably operated gas engines during the last 3 yr.

The installation at Peoria, which has just been placed in operation, is one of the outstanding plants of this type in this country. It was designed and installed under the direction of John R. Longley, District Engineer of the Sanitary District, who was formerly with consulting engineers Greeley & Hansen of Chicago. Mr. Longley came to Peoria to aid in the construction of the treatment plant and has remained as its chief engineer. Greeley & Hansen were employed as consultants on the new power development project.

Gas Has Heat Value of 500 to 600 B.t.u. Per Cu. Ft.

Aside from the rather complex chemical and bacteriological actions involved, the process of producing the power from this gas is relatively simple. The sewage from the Sanitary District of Peoria, after being separated from the liquids, is pumped into large "digestion" tanks in which the gas is generated. The gas is a mixture of various gases but it consists mostly of methane. While the composition of the gas varies according to the character of the sewage delivered, it runs fairly constant and a typical analysis is as follows:

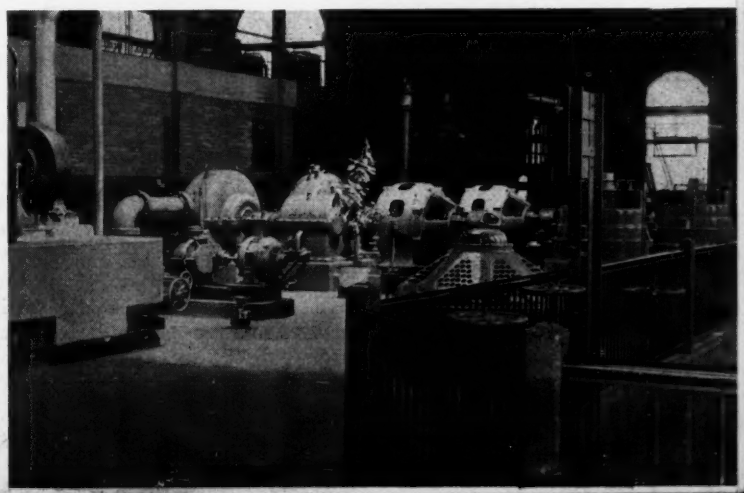


Fig. 4. General view of interior showing blower units and pump motors

Fig. 5. The large Connersville blower and its gas engine driver in the extension room

passes through Connersville positive displacement meters and Crawford gas pressure regulators to the intake manifolds of the gas engines. In case more gas is produced than can be used by the engines and stored in the gas holder, an excess pressure valve is provided through which the gas escapes to a burner and it is burned in the atmosphere. A pilot light is provided to ignite this gas.

There are two gas engines, one driving a large Connersville blower supplying air to the aeration tanks of the sewage treatment plant and the other driving an electric generator which supplies current to the electrically operated pumps and other equipment in the plant. In other words all the power generated is used in the plant itself for operating pumps and blowers necessary for the operation of the sewage disposal works.

Before these gas engines were installed all of these pumps and blowers were driven by electric motors sup-

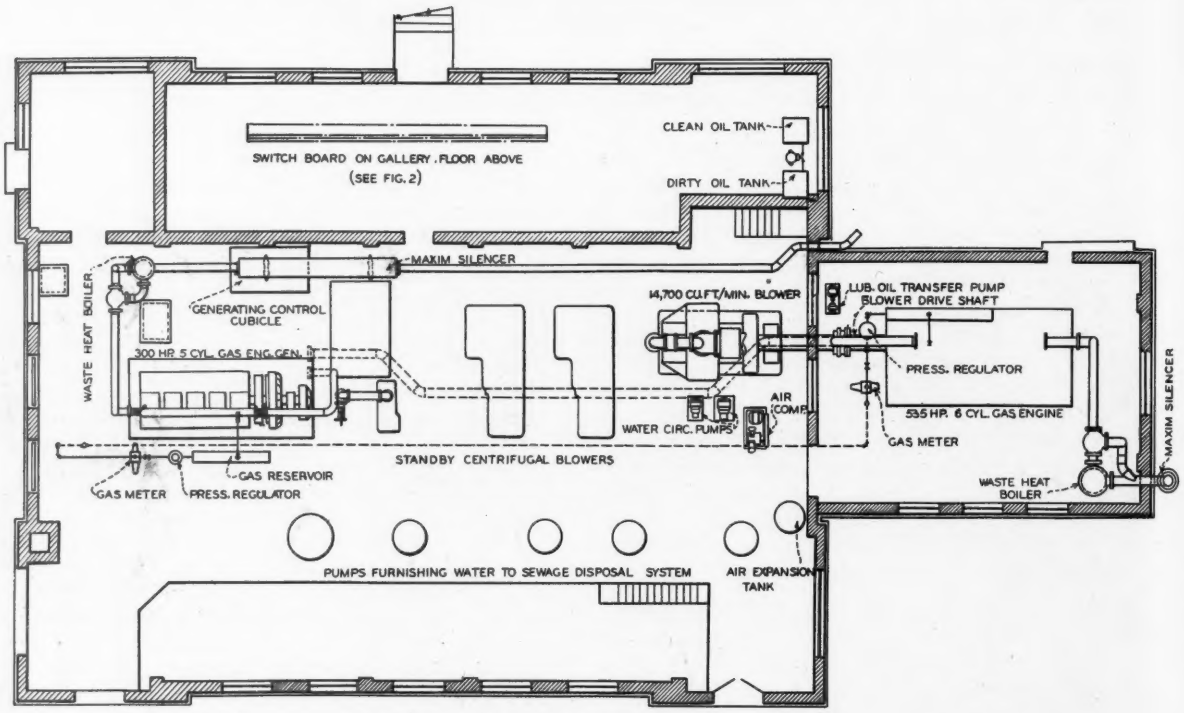


Fig. 6. Plan of station showing arrangement of equipment

Methane ..... 60 to 65 per cent
Carbon dioxide ..... 32 to 38 per cent
Nitrogen ..... 2 to 3 per cent
Hydrogen Sulphide..... 50-100 gr. per 100 cu. ft.

Ordinarily, the gas will have a net heat content of from 500 to 600 B.t.u. per cu. ft.

The gas collects at the top of the digestion tanks under pressure and flows through iron oxide purifiers where the hydrogen sulphide is removed and then directly into the mains supplying the gas engines. A 50,000 cu. ft. capacity single section gas holder is provided which serves a reservoir and also as a pressure regulator. This gas holder as will be noted from the schematic diagram floats on the line between the purifiers and the gas engines. From the gas holder the gas

plied from the lines of the local public service company through a 13,000-2300 v. stepdown transformer bank located outside of the building. These transformers and the tie line to the public service system remain but as a result of the gas engine installation practically no current is purchased from the outside company. The tie line is there, however, to serve as an

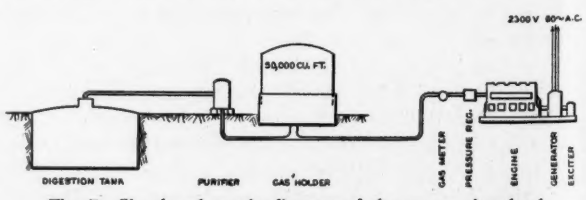


Fig. 7. Simple schematic diagram of the process involved

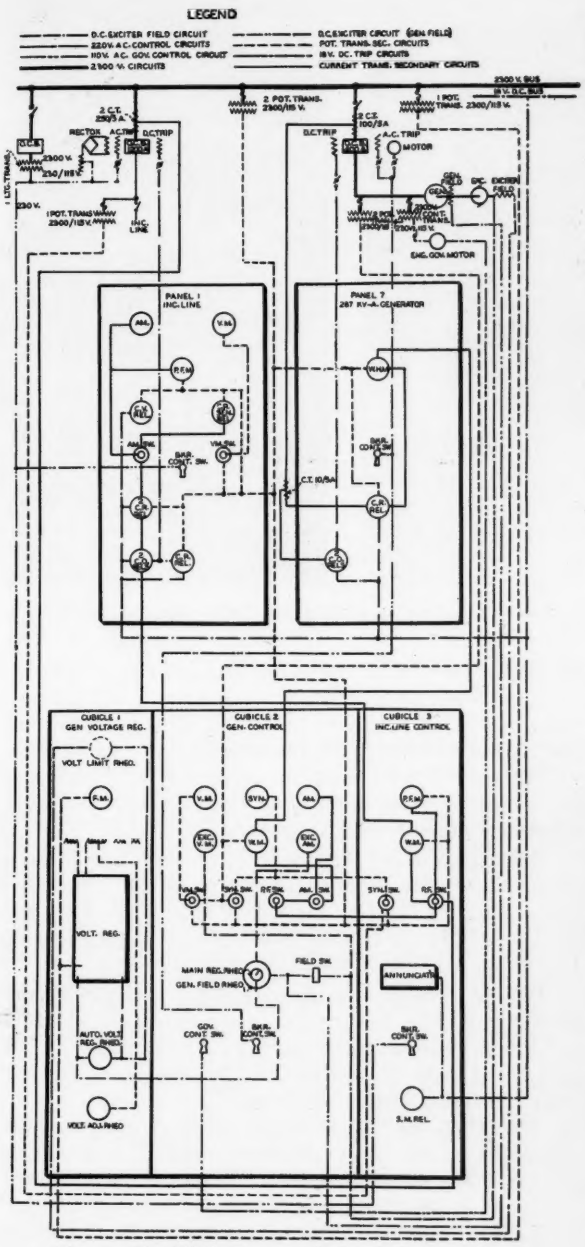


Fig. 8. Simplified diagram of electrical connections

emergency or auxiliary source of power when necessary.

General Arrangement of Equipment

The general arrangement of equipment in the station is shown in Fig. 6. The two gas engine units, it will be seen, are at opposite ends of the building, the one driving the Connersville blower being located in an extension to the main building. This extension was built especially to accommodate this unit. Originally the Connersville blower was motor driven and set at right angles to the position it now occupies. When the change was made, the motor was removed, the blower turned at right angles and the shaft extended through the wall so that it could be coupled to the shaft of the gas engine on the other side.

There are five pumping units, all Worthington centrifugal units, mounted some 25 ft. below the floor and driven by vertical shafts from motors installed on the main floor of the station. Two of these units are driven by 100-hp. induction motors, two by 60-hp. induction motors and one, the largest, by a 125-hp. 100 per cent power factor, synchronous motor.

In addition to these large pumping units which are for the sewage disposal plant, there are two small units for circulating cooling water to the gas engines. These are located on the site of the motor which formerly drove the large Connersville blower. They are Worthington centrifugal units, direct connected to 10-hp., 60 cycle, 220-440 v. motors, the motors being supplied by the Master Electric Co. at Dayton, Ohio.

In addition to the gas engine driven centrifugal compressor used for supplying air to the aeration tanks, three motor driven, standby compressors are provided. Two of these are 10,000 cu. ft. per min., 8½ lb. pressure De Laval units driven through De Laval gears by Westinghouse 450-hp., 2300 v. synchronous motors while the third is a small Connersville unit driven by an Allis-Chalmers induction motor. The gears are used to effect a speed increase of some 3½ times between the motors and the blowers. The motors operate at 1200 r.p.m. while the blowers run at 4200 r.p.m.

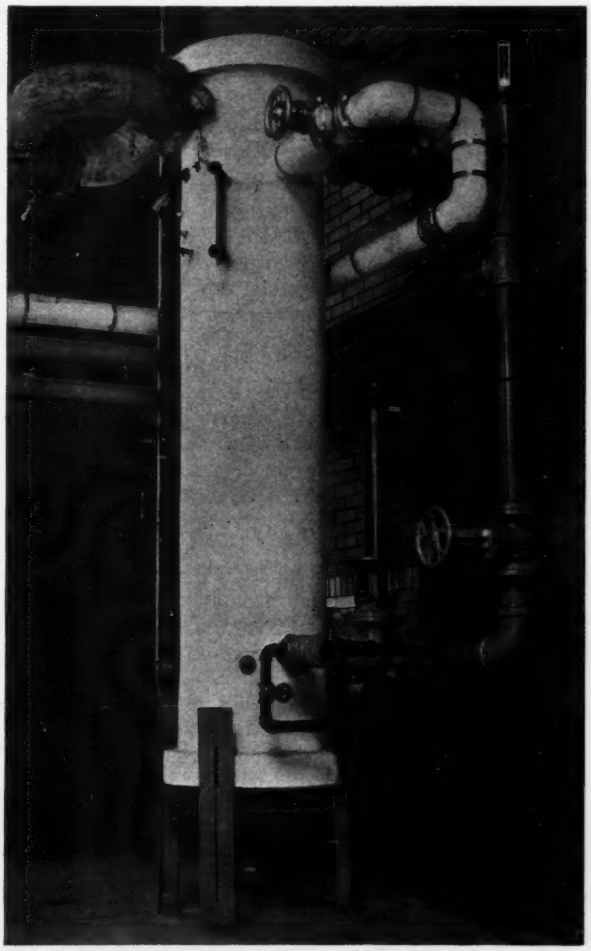
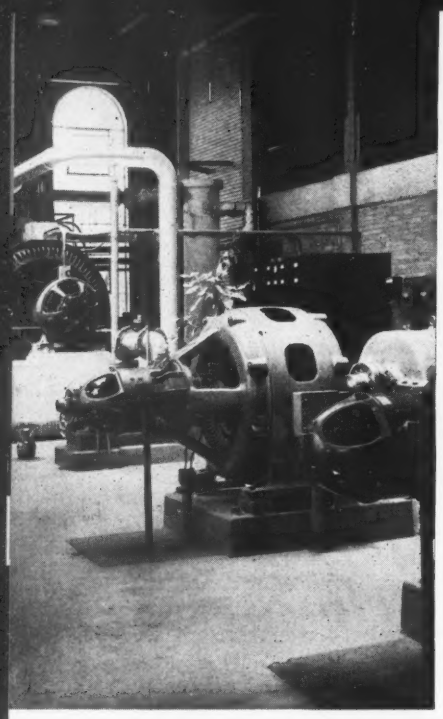
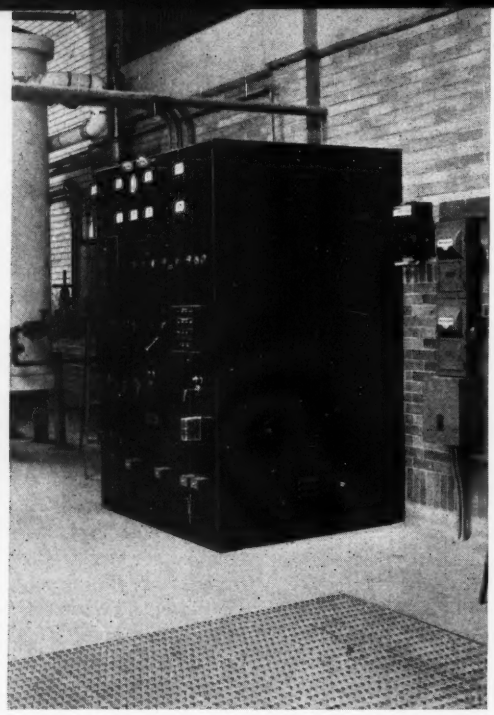
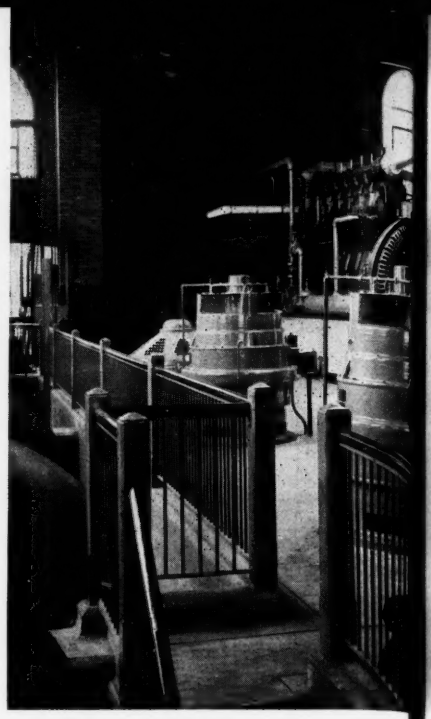


Fig. 9. One of the waste heat units







Figs. 10, 11 and 12. General views in the station. Center view shows the cubicle controlling the electric generating unit

Finally, in addition to the equipment already indicated, there is a small air compressor, provided for starting the gas engines. This is a Worthington V-type unit driven by a 7½-hp. G.E. induction motor, equipped with a receiver and a magnetic unloader.

Gas Engine Units

The engine driving the blower, as has been mentioned, is located in a new addition to the building. This being the case its installation involved no unusual problems. It is mounted on a separate concrete foundation separated from the building proper by resilient cork to eliminate vibration.

The installation of the generator engine, however, presented a problem in that it had to be installed on the floor of the main station where, because of the pumps below, it was difficult to construct a separate foundation. A way out of the difficulty was found in the use of vibro-dampers, by means of which it was possible to set the entire unit—engine and generator—directly on the existing concrete station floor. The manner in which this was done is readily apparent from the accompanying photographs of the unit. The entire unit, it will be noted, is mounted on a heavy reinforced concrete base about 2½ ft. thick which rests upon the Korfund Vibro dampers. This method of support has been found very effective; the vibro dampers suppressing all transmission of vibration between the engine bed and the floor.

Both gas engines are Worthington units, the one driving the generator being rated at 300 hp. and the unit driving the blower at 535 hp. Both units are fitted with Manzel forced feed lubricating systems, Connersville gas meters, Crawford gas regulators, Minneapolis-Honeywell control devices, and Maxim silencers.

The generating unit operates at 400 r.p.m. and drives a 200-kw., 0.7 power factor, 2400 v., 3 phase, 60 cycle General Electric generator and a 7.5-kw., 125 v. exciter. The exciter is shunt wound and operates in conjunction with an automatic voltage regulator.

The blower engine, which is rated at 535 hp., operates at a speed of 327 r.p.m. at which speed it drives the blower directly. This blower has a displacement of 44.9 cu. ft. per revolution or approximately 14,700 cu. ft. per min. at the engine speed. It maintains a discharge pressure of 8 lb. per sq. in.

Both engines are arranged for air starting and both with exhaust gas boilers. These are Davis "Paracoil" units, made by the Davis Engineering Corp. They are used to generate steam for heating coils in the digester tanks and also for heating the buildings in winter.

One of these, the one used in conjunction with the blower engine, is designed to generate 500 lb. of steam per hr. at 10 lb. gage pressure with inlet water at 100 deg. F. when supplied with 7000 lb. of exhaust gas per hr. at a temperature of 800 deg. F.

The other, used with the generator engine, is guaranteed to deliver 210 lb. of steam under the same conditions when supplied with 3000 lb. of exhaust gas per hr. at a temperature of 800 deg.

Both of these waste heat units are designed so that they may be used as hot water heaters if desired. They are capable of being operated with exhaust gas temperatures of 1000 deg. F. either as boilers or water heaters.

The water system is rather interesting. Jacket water leaving the engine is passed through the waste heat boiler and then through heating coils in the digestion tanks. It also passes through coils in the gas holder and purifiers for protection in winter months. It is then returned to the buildings and if the temperature is not sufficiently low, it is turned through coils suspended in the aeration tanks and finally back to the engine. The operation of this system is entirely manual; it requires little attention, requiring only the adjustment of a valve once every several days. The water system of course is entirely closed.

The waste heat boilers or heat exchangers are located close to their respective engines.

Electrical Features

Current is generated at 2300 v. and this is delivered directly to the main switchboard on the balcony along one side of the room. This is a modern switchboard containing panels not only for distributing current to the various motors in the station but also for controlling the incoming power from the public service company lines. This power, as explained before, is delivered at 13,000 v. to a bank of transformers in which it is stepped down to 2300 v. for station use. All switching is done on the low side of the transformers. The new generating unit is arranged so that it can be operated in synchronism with the power company system but normally it operates separately, no power being drawn from the utility system.

For the control of the generator a separate switching unit consisting of a three panel cubicle is provided. This is located on the main floor of the station directly opposite the generator. It contains the voltage regulator, exciter panel, generator control equipment and an annunciator for the engine protective devices. A simplified diagram of the electrical control circuit is shown in Fig. 8. This shows the cubicle below and the two panels of the main switchboard associated with the system above. One of the latter, it will be noted, controls the incoming power while the other controls the generator.

The gas engines do not have constant attendance so that automatic shut down devices have been provided for each machine consisting of contact devices which functions in case of high oil temperature, low oil pressure, high circulating water temperature and failure of circulating water supply.

In addition to the ordinary overcurrent relays in the incoming power line directional overcurrent relays have been provided to open the line breaker in case the Power Company's feeder line be opened at the substation. As the feeder has an automatic reclosing breaker at the substation rather accurate timing of the breaker action at the sewage plant is essential. The generator breaker also is opened by directional overcurrent relay to provide against motoring of the generator. The relays have a time delay feature so that momentary surge of relative small amount, such as would occur in synchronizing, etc., will not open the breakers.

In order that the operator may be informed as to the source of trouble in the event that some of the automatic features operate during his absence, a 12 drop annunciator has been provided which has a drop for each of the engine safety cutout devices, the main line breaker and the directional relays in the main line and in the generator leads. The annunciator is so wired that if any drop falls an alarm is sounded and in addition if one of the engine safety devices operates the corresponding gas supply valve is automatically closed and the ignition circuit grounded so as to stop that engine as soon as possible leaving the other in operation. It is also so arranged that when one drop operates no other in connection with the same engine or circuit breaker will operate until the first is reset, thus the operator is able to determine the primary cause of trouble or shutdown.

List of Equipment

Engine generator unit—300 hp., 5 cylinder, 400 r.p.m. gas engine Worthington Pump & Machinery Corp. direct connected to 200 kw., 2400 v., 400 r.p.m., 3 phase, 60 cycle generator, with 7.5 kw., 125 v., 60 amp., 400 r.p.m. shunt wound exciter—General Electric Co.

Blower engine unit—534 hp., 6 cylinder, 327 r.p.m. gas engine, Worthington Pump & Machinery Corp. direct connected to 14,700 cu. ft. 8 lb. per sq. in. blower—Roots-Connersville Blower Corp.

Exhaust Silencers—Maxim Silencer Co.

Engine lubricators—Manzel Bros. Co.

Gas meters on engines—1—9000 cu. ft. per hr., 1—12,500 cu. ft. per hr., with Veeder counters on both—Roots-Connersville Blower Corp.

Gas pressure regulators—Crawford Sensitive Gas regulators—Equitable Meter Co.

Engine protective devices — Minneapolis-Honeywell Regulator Co.

Circulating pumps—1—250 g.p.m., 1—150 g.p.m., both designed for 35 ft. head, driven by motors made by the Master Regulator Co., Worthington Pump & Machinery Corp.

Air compressor for engine starting—V-type, 5½ by 3⅛ by 3½ in. with receiver and magnetic unloader and driven through Goodyear Emerald Cord V-belt by a 7½ hp. General Electric 1730 r.p.m. induction motor—Worthington Pump & Machinery Corp.

Waste heat exchangers—1—500 lb. per hr., 10 lb. per sq. in., 100 deg. F. inlet water, 7000 lb. exhaust gas at 800 deg. F. per hr. "Paracoil" heater—Davis Engineering Corp. 1—210 lb. per hr., 10 lb. per sq. in., 100 deg. F. inlet water, 3000 lb. exhaust gas at 800 deg. F. per hr. "Paracoil" heater—Davis Engineering Corp.

Switchgear equipment—3 panel cubicle, generators, regulator and power line control—Westinghouse Electric & Mfg. Co.

Conclusion

Aside from the unusual features which form the basis of its operation it will be evident that this little station has many features of engineering interest in itself. It is attractively designed and is nicely located. The Sanitary District has 200 acres of land, 50 acres of which are immediately inside the levee representing the improved area. This area is landscaped with spacious lawns and trees and its appearance gives little evidence of the sordid material it disposes.

Fifteen million gallons of sewage pass through the treatment plant daily. Intercepting sewers pick up the sewage from the city's trunkline sewers. The district's waste flows to a large sump deep beneath the pumping station from which it is pumped or lifted to such an elevation that it flows through the treatment plant without any further pumping. The bacteriological treatment of the solids requires from 15 to 30 days.

In concluding this description we acknowledge our indebtedness to John R. Longley, District Engineer of the Greater Peoria Sanitary and Sewage Disposal District, for courtesies extended while inspecting the plant and to A. C. King, Consulting Electrical Engineer of Chicago, for information furnished regarding the electrical system.

The superposition power plant offers an attractive way of utilizing existing equipment without sacrificing the high thermal efficiencies of the modern high pressure plant. In this article the author discusses the advantages of the superposition plant from both the thermal as well as the financial viewpoint.

The Superposition Power Plant

By NORRIS D. GOVE
Design Engineer
Westinghouse Electric & Manufacturing Co.

IT IS TODAY common practice to operate turbine installations that have been depreciated to a very low value. In fact, their operation is based on that very lack of value. The reason, of course, is that the total cost of current at the switchboard is the sum of fixed charges and operating costs, so that when fixed charges are reduced by using depreciated equipment, a somewhat larger fuel bill may be permissible. In most systems, these relatively poorer units are used for peak loads and standby service, which still further favor this practice since the fixed charges are continuous and the operating costs are based chiefly on the output. This practice is not unknown outside the Central Station ranks. The man who drives an oil burning automobile of ancient vintage is taking advantage, perhaps through necessity, of this same principle.

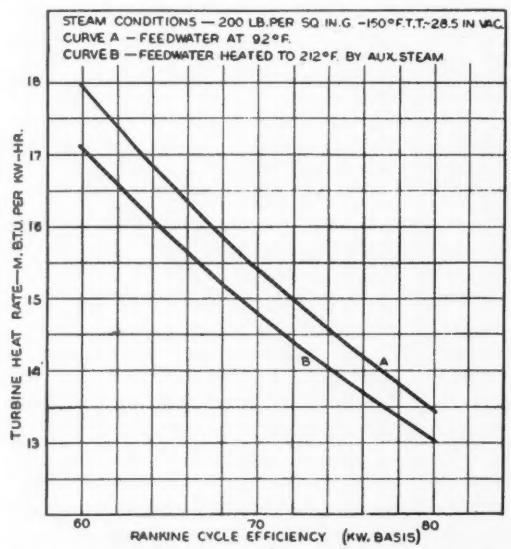


Fig. 1. Curves showing the heat rate of a typical old plant before superposition

When it is considered that, with proper selection of the operating cycle, standard turbines can be bought today with heat rates of 10,000 B.t.u. per kw-hr. in capacities as low as 15,000 kw., and that these turbines will produce current at a fuel cost of about 2 mills per kw-hr. the old installations seem very much out of date. Figure 1 shows the turbine heat rates over a range of efficiencies for steam cycles that were typical 20 yr. ago. Curve A is the seldom used condensing cycle with condensate pumped direct to the boiler, while the lower curve, B, is based on heating the feed to 212 deg. F. with exhaust steam from auxiliaries. The turbine heat rate is considered as improved in proportion to the benefit to the whole plant. This is the kind of cycle and turbine that raise the operating costs to 4 mills or more.

As system loads increase more and more, load is carried by the installations described above until a point is reached when new capacity must be added. Formerly, this necessitated the purchase of a new condensing unit, with frequently the construction of a new plant at a very considerable capital outlay. The older plants were still further retired and became practically valueless. It is true that rapid advances in engineering usually reduced, somewhat, the overall cost of power, but larger capital costs kept the reduction smaller than could be desired.

An alternative proposition has come into favor during the last few years. It consists of superposing a high pressure non-condensing plant on the existing low pressure installation. With this arrangement, a high pressure boiler of 6, 9, or 12 hundred pounds pressure delivers steam to a non-condensing turbine, which exhausts into the old boiler header or often directly into

a low pressure turbine or turbines. With the latter arrangement, the combined elements operate as a simple cross-compound unit. The size of the new unit depends chiefly on the selection of the new pressure and the steam capacity of the old turbines. These factors usually permit an increase in capacity of from 50 to 100 per cent. The more common initial conditions considered are 1200 or 1250 lb. per sq. in. gage, 900 deg. F. total temperature and 650 lb. per sq. in. gage, 825 deg. F. total temperature. With these pressures and temperatures superposed on an existing 200 lb. plant, the increase in capacity is 60 to 100 per cent for the former and 40 to 60 per cent for the latter, the larger increases in each case applying to the least efficient existing turbines. Figure 2 shows this increase in curve form, the initial installation being taken as 20,000 kw. with steam conditions of 200 lb., 150 deg. and 28½ in. vacuum.

Coincident with the large increase in capacity with superposition is the great reduction in turbine heat rate. This is readily understandable when one considers that approximately equal amounts of heat are discharged to the condenser before and after superposition. Heat rates of around 10,000 B.t.u. per kw-hr. are to be expected with 1200 lb., 900 deg. F. total temperature and 11,000 B.t.u. per kw-hr. with 650 lb. 825 deg. F. total temperature. Figure 3 shows the general trend with variations in efficiency of the old unit.

The thermal advantages of superposition can be demonstrated easily and simply. The commercial aspects, while usually as desirable, are more difficult to portray in general terms, since they are so greatly modified by local conditions. For instance, the overall cost of condensing plants has varied from $50 per kw. up to three times that amount, and it is reasonable to expect that the cost of a superposition plant will also vary over a considerable range. The only way to make any comparison is to figure costs of new condensing capacity based on local conditions and the desired level of engineering and architecture. Then calculate the cost of the superposition plant, keeping engineering design on the same level and remembering that the superposition unit must go into the old plant or an addition thereto. It is the consensus of opinion among engineers today that such a comparison will

Existing Plant			
Rating	20,000 kw.		
Steam conditions	200 lb. per sq. in., 150° F. superheat, 28½ in. vacuum		
R.C. Eff. (Turb. and Gen.)	70%		
Feedwater temperature	212° F.		
Turbine heat rate	14,790 Btu/kw-hr.		
Superposition Unit			
Rating	14,580 kw.		
Steam conditions	1200 lb. per sq. in., 900° F.T.T.		
Boiler efficiency	85%		
Complete Plant			
Combined rating	34,580 kw.		
Final feed temperature	375° F.		
Combined turbine heat rate	9910 Btu/kw-hr.		
Allowance for auxiliaries	6%		
Net capacity	32,545 kw.		
Station heat rate	12,402 Btu/kw.		
Load factor	70%		
Yearly net output	199.5 million kw-hr.		
Cost of coal per ton	$4.00		
Caloric value of coal	13,000 Btu/lb.		
Fuel cost per kw-hr.	1.91 mills/kw-hr.		
Fuel cost per year	381,000.		
Value of old plant—dollars/kw.	0	50	100
Total value of old plant	0	$1,000,000	$2,000,000
Added investment—dollars/kw	100	100	100
Added investment	$1,450,000	1,450,000	1,450,000
Total cost of plant	1,450,000	2,450,000	3,450,000
Fixed charges at 15%	217,500	367,500	517,500
Fuel cost per year	381,000	381,000	381,000
Labor, maintenance supplies	70,000	70,000	70,000
Total annual cost	668,500	818,500	968,500
Total cost of power—mills/kw-hr.	3.35	4.10	4.85

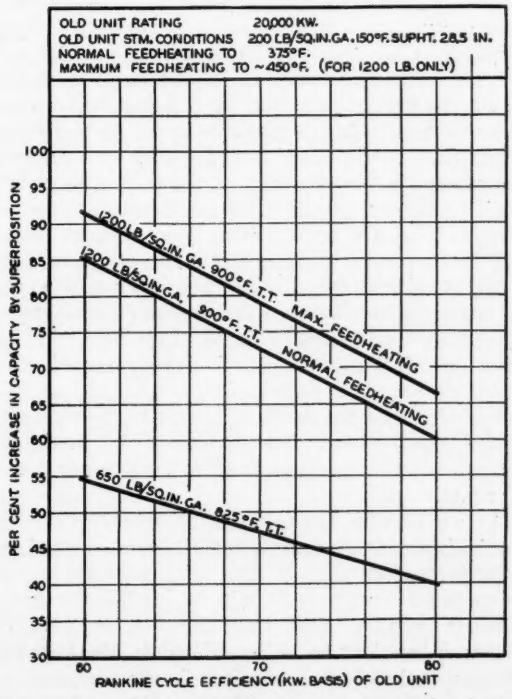


Fig. 2. Curves showing typical increases in plant capacity by superposition

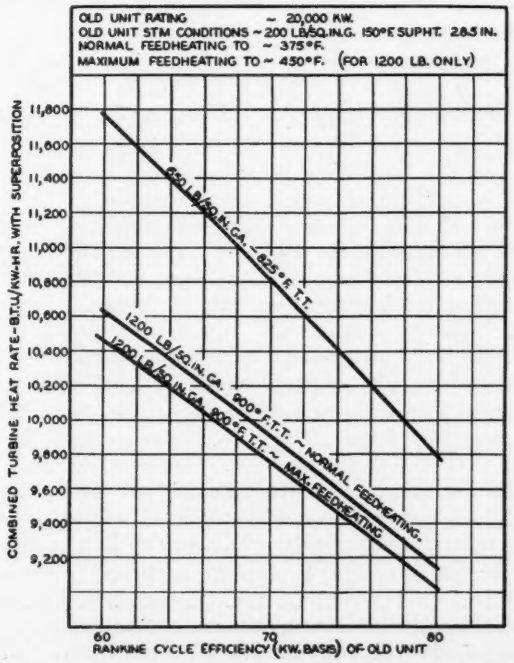


Fig. 3. Curves showing typical heat rates with superposition

usually favor the superposition plant, although there are cases where the reverse is true. Good engineerig will decide each case on its merits, taking into consideration every aspect of the situation.

In the consideration of the superpostion idea, an elementary cost tabulation which can be varied for specific instances may be of interest. The values are taken partly from Fig. 1, 2 and 3 and partly from an actual plant estimate.

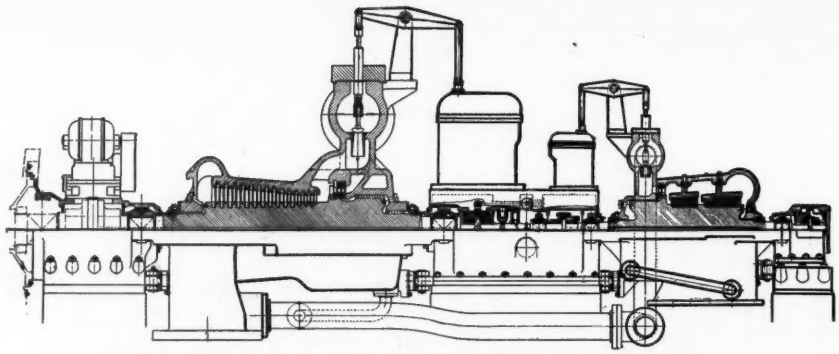


Fig. 4. Longitudinal section of largest 3600 r.p.m. turbine ever built, a 50,000 kw. superposition turbine with initial conditions of 1200 lb. per sq. in., 900 deg. F. total temperature

Whatever the value of this tabulation, one important conclusion may be drawn. The plant that can develop power at a fuel cost of around 2 mills per kilowatt sets for itself a value comparable to that of the best condensing plants and that value applies, at least to a considerable extent, to the essential component parts. Consequently, the purchase of the superposition unit improves the whole plant. It takes the obsolescent, standby unit and makes it an integral part of an economical, modern and valuable installation, adding decades to its useful life and appreciating, greatly, its value.

That the comparative economy of superposition is widely established is evidenced by an analysis of the central station turbines purchased during the first five months of 1936. Of eleven turbines bought, totaling 275,000 kw., only four with a combined rating of 67,500 kw. were condensing units. Of the other seven, six were 1200 lb., 900 deg. (approximately) superposition turbines, and the seventh a 625 lb. superposition unit of 12,500 kw. rating. 75.5 per cent of the purchased capacity was in superposition turbines. Incidentally, one of these purchasers of condensing units expects that his next machine will be of the non-condensing type. The conclusion seems inescapable that engineers must consider carefully the economics of the superposition plant.

New Hydrogen Cooled Turbine Generators

OUTSTANDING among equipments now under construction in the turbine shops of the General Electric Company at Schenectady are two 60,000-kw. hydrogen-cooled turbine generators, and a 75,000-kw. unit for another utility's generating plant.

Windsor Station

The two 60,000-kw. turbine generators under construction for the Windsor Station of the Ohio Power Co. and the West Penn Electric Co., at Beach Bottom, W. Va., will be unusual in several respects. The turbines will be the largest high-pressure, non-condensing, high-temperature machines yet built; and the generators will be the largest to operate at 3600 r.p.m., as well as the largest to be hydrogen-cooled. The machines are designed for 1250 lb. gage pressure, 925 deg. F. total temperature, and 235 lb. gage back pressure. They will be superimposed on the existing equipment.

The Windsor plant serves both the Ohio Power Co. and West Penn Electric Co. systems, and is jointly owned by the two companies. The new turbine generators will be used to provide for increased demand and to improve the overall efficiency of the station. The units are expected to be in service late in 1938.

Hydrogen cooling as applied to turbine generators is a new engineering feature. It has, however, been used extensively in synchronous condensers. A few months ago the Appalachian Electric Power Co. of Logan, W. Va., another operating company of American Gas & Electric, ordered a 40,000-kw. turbine generator. That equipment, now under construction at Schenectady, is the first to have hydrogen cooling.

Hydrogen cooling makes possible, economically, large generators at 3600 r.p.m. which if air-cooled would have greater air friction and rotational losses. Hydrogen reduces these windage losses to 10 per cent of what they would be with air, and this results in an improvement in the efficiency of the generator of from 0.6 to 1.1 per cent, depending upon the size of the unit. Hydrogen requires considerably less pressure to circulate the necessary volume and it has many times the thermal conductivity of air. It also removes more heat from a given surface for the same temperature drop. Although hydrogen results in a slight increase in capacity for a given physical size, the electrical characteristics still determine the capacity of the unit. Because of the more expensive construction required with hydrogen cooling, its use cannot be justified in small sizes, but it makes possible large generators at 3600 r.p.m.

The capacity of the Cahokia Station of the Union Electric Light & Power Co. of Illinois, at St. Louis, will be increased early in 1938 with a 75,000-kw. turbine generator. The unit will be similar to another 75,000-kw. station, also built by General Electric, which was installed in 1928. The unit, the largest to have been ordered by any utility in recent years, will operate at 315 lb. pressure, 725 deg. F., and 1 in. absolute back pressure.

Treatment *of* Silica *for* High Pressure Boilers

Increasing boiler pressures have aggravated the difficulties encountered with silica in boiler feedwater. Several methods of alleviating silica troubles are considered here

By S. E. TRAY*

AMONG the various scale forming constituents found in the waters of this country, silica occupies a rather unique position. Comparatively little is known as to its characteristics in solution at high temperatures and yet the successful operation of high pressure steam plants depends largely on the control and elimination of silica deposits both in boilers and turbines. The magnitude of this problem is demonstrated by the attitude of one of the country's largest industrials, now operating several high makeup plants at pressures of 600 lb. and higher. Serious consideration has been given recently to building additional new plants at low pressures, with a sacrifice of efficiency, because of operating difficulties at the higher pressures due to silica deposits. This problem affects condensing plants as well as those with large makeup requirements, although it is intensified considerably in the latter type of plant where steam is used for process and the condensate is not returned to the boiler.

Silica is one of the most abundant compounds found in nature, occurring in rock formations, sand and gravel, and is readily dissolved by water flowing through them. The silica content of natural waters varies in different localities, but is generally higher in softer waters. Thus, the Pacific Northwest and the Gulf Coast area with relatively soft waters show a high silica content, while some of the hard waters in the Middle West contain very little. The usual tests for hardness indicate only calcium and magnesium and are of no benefit in checking for silica which must be determined by a complete chemical analysis. At boiler pressures below 250 lb., little difficulty from silica is encountered, and the usual chemical treatment for the prevention of carbonate and sulphate scale is sufficient. At higher pressures and temperatures, however, silica becomes less soluble and increasingly difficult to control. This is especially true at points of maximum steam generation in the boiler, such as water walls and the lower rows of tubes nearest the furnace. At these points, the rate of steam generation causes rapid concentration of boiler water salts, and the temperature of the heating surfaces is higher than in other parts of the boiler.

Unfortunately the silicates are not simple compounds as are the carbonates and sulphates, and their properties are much more difficult to determine. Thus there is no direct data on the solubility of calcium silicate since it tends to hydrolyze on heating in solution and there is no absolute ratio between the amount of silica and calcium present. Figure 1 shows the solubility of calcium sulphate and calcium carbonate at various pressures but no similar curve is available for calcium silicate. From investigation of a large number of silica deposits, however, it is apparent that the solubility curve of silica is similar to that of calcium carbonate rather than sulphate in that it is more nearly constant over the entire range of operating pressures, and decreases with increase in temperature. Also, it appears to lie between the carbonate and sulphate curves and this becomes an important factor in the prevention of silica deposits as will be noted later. Because of the many forms in which silica may exist,

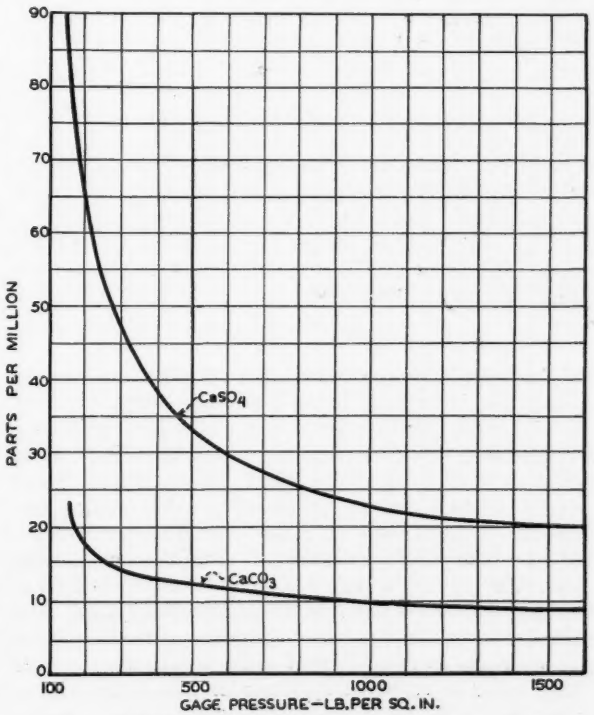


Fig. 1. Solubility of calcium sulphate and calcium carbonate

*Allis Chalmers Mfg. Co., Feedwater Treating Dept.

chemical analyses of silicate scales only indicate the quantity of silica and other constitutents present, without regard to their crystal formation or physical properties. Powell[1] has pointed out the advantages of microscopic studies to identify the crystal structure and the development of the growth of such deposits.

In a majority of cases silica deposits are very thin, but because of their density, have the lowest heat transfer rates of any type of scale. In high pressure boilers, these thin layers of scale cause tube failures very quickly from the blistering and rupture of over-

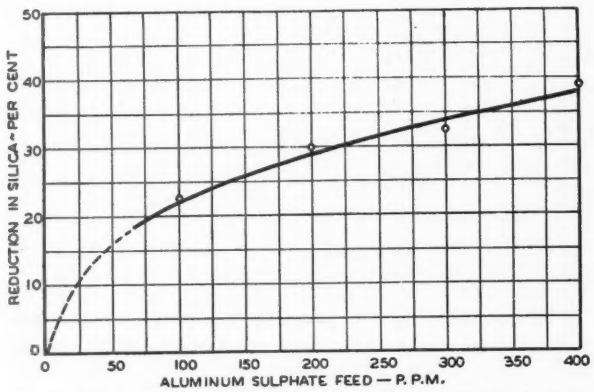


Fig. 2. Effect of aluminum sulphate on reduction of silica in hot process softener

heated metal. As little as 3 p.p.m. of silica in the feedwater has been found to give trouble from deposits in boilers operating with water of zero hardness. Two general types of silica deposits are found in boilers; a normal calcium silicate scale of the form $CaO{\cdot}SiO_2$, and a double silicate of sodium and aluminum of the form $Na_2O{\cdot}Al_2O_3{\cdot}4SiO_2$ in which little calcium or magnesium is present. This latter type of scale, termed analcite, is formed more readily at pressures above 400 lb. and is dependent on the concentration of alumina which is present in many natural waters. The acompanying table illustrates several types of silica scales deposited under various operating conditions. Samples A and B are excellent types of normal calcium silicates, while C shows a combination of sulphate and silica. Sample D, from a water wall tube, is a good example of analcite, as is also E. In these latter deposits, practically no calcium or magnesium is present as the scale formed in water of zero hardness in the presence of phosphate.

External Treatment

Treatment for the prevention of silica deposits in boilers has in general fallen into two classes, external and internal. Neither lime-soda nor zeolite softening provide effective treatment since soluble silica passes unchanged through the softener. Some attention has been given to additional treatment to reduce silica outside the boiler, chiefly in connection with hot process softeners, but little progress has been reported in this field. The methods proposed include the use of magnesium salts and the soluble sulphates of zinc, iron and aluminum. The use of magnesium salts is based on the decrease in solubility of silica in the presence of magnesium as reported by Straub[2]. Some success has been noted on waters of low silica content and low hardness, but the method has not been found suitable for all conditions. Zinc sulphate, as used under Reimer's patent, has been reported as having been successfully used in Germany, but there are no installations in this country which have proven satisfactory to date. Aluminum sulphate has also been proposed, and Fig. 2 shows the per cent reduction obtained on a high silica water by this method. These tests were in conjunction with a hot lime-soda softener and while some reduction occurs, the cost of treatment is excessive. In addition, when alum is used to the extent of 400 p.p.m. in the feedwater, softener operation is extremely difficult to control and soluble salts in both feedwater and boiler water are materially increased.

Ferrous sulphate likewise has been recommended to reduce silica in both cold and hot process softeners. Several installations of this type have been made, but no decrease in soluble silica has been noted. Where colloidal silica is present, as in river water, coagulation with ferrous sulphate will remove it, but in ordinary waters it has been shown that only a small percentage of the total silica is present in this form.

Internal Treatment

Internal treatment for the prevention of silica deposits has been more successful, although even now positive results are often lacking. In the boiler the problem has been approached in two ways, (a) by keeping silica in solution, and (b) by precipitating silica out of solution as a sludge. As a means of keeping silica in solution, the sodium phosphates prove effective by removing all the calcium and magnesium hardness which might otherwise combine with silica. This keeps the silica in the form of soluble sodium silicate and eliminates any tendency for normal calcium silicate formation. Unfortunately a pH value of 11.5 or higher is necessary to maintain silica in solution and to keep the solubility of calcium phosphate at a minimum. This increase in alkalinity requirements of the boiler water often contributes to carryover at higher ratings. The boiler water, under this type of treatment, carries a high silica content and, when carryover occurs, deposits silica both in superheaters and turbines. Blade deposits analyzing 90 per cent SiO_2 have been found which are extremely difficult to remove, as they generally are not water soluble.

Another difficulty encountered when silica is kept in solution is the tendency for analcite formation in the presence of alumina. R. E. Hall has pointed out that phosphates cannot prevent this type of deposit because of the solubility of aluminum phosphate in alkaline boiler water, and suggests that efforts be made to eliminate all traces of alumina from the feedwater. The extreme solubility of alumina, however, makes this difficult, more especially when as little as 0.2 p.p.m. in the feedwater has been found to contribute to analcite formation. The occurrence of this type of scale, as well as the presence of silica deposits in superheaters and turbines has lead to the development of a method designed to precipitate silica out of solution, thus rendering harmless the small traces of alumina.

This removal of silica as a sludge in the boiler can be accomplished with the use of iron products which have no appreciable effect on the alkalinity or the

[1]Proc. ASTM. Vol. 34, Part II, 1934.
[2]Ind. Eng. Chem. Vol. 28, 36 (1936).

soluble concentrations in the boiler water. The reaction is similar to that proposed for external treatment in that silica precipitates with the iron in alkaline solution. A pH value of only 9.6 is required for this reaction, thus eliminating the necessity for high alkalinities in the boiler. The boiler water is generally held at pH 10.5 which insures complete precipitation of silica as well as protection from corrosion. Since the solubility of silica appears similar to the carbonate, as previously mentioned, this precipitation would occur throughout the boiler as well as at the hot tube surfaces. The silica thus removed is not available either to combine with soluble alumina in the boiler, or to contribute to deposits in superheaters and turbines. The silica, together with the iron, exists as a

Types of silica scales deposited under varying conditions

	A	B	C	D	E
Type of Boiler	Bent tube	Straight tube	Straight tube	Straight tube	Bent tube
Pressure lb.	400	600	600	600	600
Location of scale	Front bank	Water Wall	Lower row	Water wall	Water wall
Silica, SiO_2	42.2	40.0	13.6	36.2	26.7
Ferric oxide, Fe_2O_3	2.0	4.8	9.3	6.1	10.2
Aluminum oxide, Al_2O_3	1.0	-	2.4	20.7	18.4
Calcium oxide, CaO	40.1	40.7	31.4	3.7	8.2
Magnesium oxide, MgO	4.1	5.4	3.0	1.8	0.7
Phosphorous Pentoxide P_2O_5	-	5.5	4.3	8.2	13.4
Sulphur trioxide, SO_3	0.6	0.5	31.0	0.1	0.6
Sodium oxide, Na_2O	-	-	-	14.7	18.1
Carbon dioxide, CO_2	4.4	Trace	1.1	Trace	2.5
Ignition loss	4.7	4.3	3.7	8.2	3.0
Total	99.1	101.2	99.8	99.7	101.8

sludge and is removed from the boiler by blowing down. The amount of sludge formed is relatively small, since the silica content of all waters represents only a small percentage of the total solids in solution, and its disposal presents no problem in boiler operation. Blowdown requirements are not increased, but as a matter of fact are often decreased, due to the lower alkalinity requirements.

Previous efforts to precipitate silica internally have been based on the formation of complex silicates of calcium and aluminum. This results in a compound similar to zeolites, with the property of exchanging calcium for sodium, thus furthering the formation of analcite. This difficulty is overcome with the use of iron, since iron is not amphoteric and does not form basic compounds with sodium or calcium in aqueous solution. Thus no complex iron silicates will form to deposit as scale in the boiler. This treatment, of course, must be used in conjunction with the ordinary softening chemicals which prevent carbonate and sulphate scale, but it is interesting to note that with the elimination of silica from the boiler water, the usual softening chemicals are more effective as scale preventives. This type of treatment has excellent possibilities when used following the conventional softener, since it provides for the removal of silica without the addition of undesirable salts to the boiler water. Its effectiveness has been demonstrated over several years in plants operating up to 1400 lb. pressure with varying makeup requirements and water conditions.

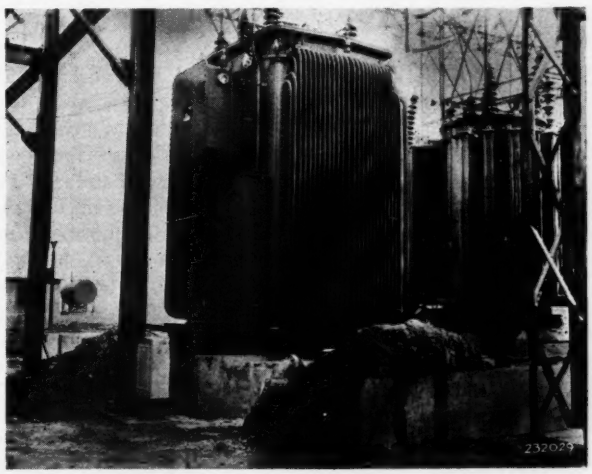
The prevention of silica deposits in boilers and turbines is a problem requiring the best efforts of both the chemist and the engineer. There is no universal treatment adaptable to all conditions. On the contrary, each plant represents a special problem in itself, to be considered in the light of the mechanical equipment installed as well as the water conditions. The treatment must fit the boiler and enable both boiler and turbine to generate their maximum output with a minimum of outage. It is only through continued research, together with the experience gained in actual plant operation, that the solution to this important problem will be attained.

Voltage Regulator Saves $8000 Annually

ONE OF the largest voltage and phase angle regulators ever built has recently been installed in a switching substation of a large power company supplying over 150,000 domestic, commercial and industrial customers.

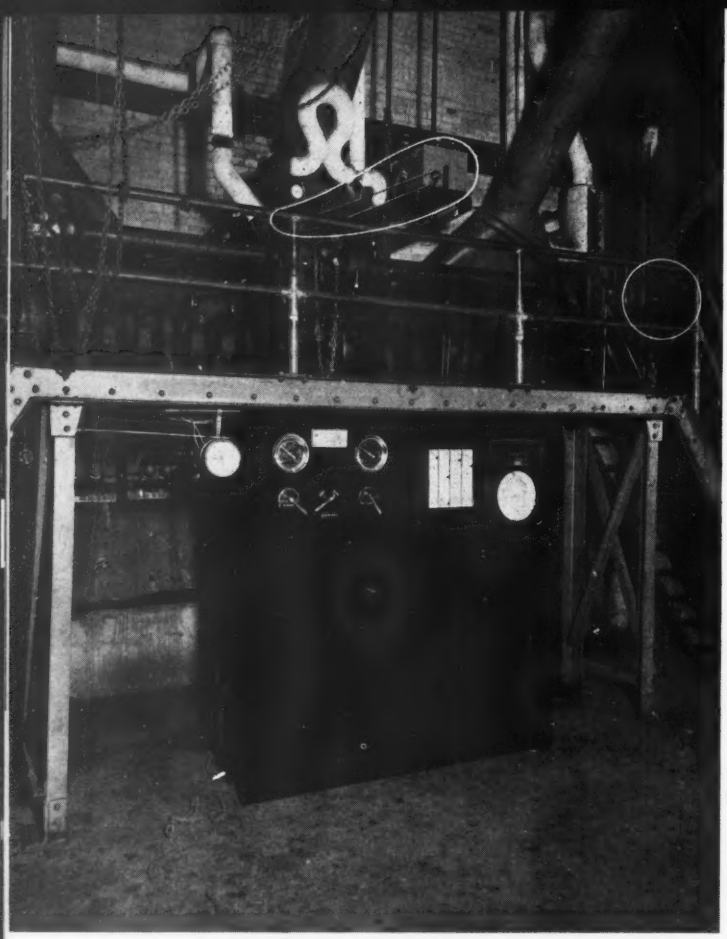
This substation is located at approximately the center of the system and is tied into three generating plants by 132,000 v. high tension lines, and a fourth plant by two 25,000 v. lines. This latter plant located in the center of a busy industrial load is obsolete as compared with the three other main plants of the system.

With the use of this new 10,000 kv-a. Westinghouse voltage regulator at the substation, this old steam plant 20 mi. away can be shut down entirely at certain periods of the year, and by boosting the voltage and advancing the phase angle at the substation, all the industrial customers surrounding this old plant can be supplied with normal voltage. Under abnormal load conditions on other parts of the system, this old station can be operated and the regulator adjusted to actually pull power from it and feed it into the entire system.



This voltage and phase angle regulator will pay for itself within three years

By the use of this regulator and by shutting down the old power plant at certain times, it is conservatively estimated by the power company engineers that this $25,000 regulator will pay for itself within three years.



COMBUSTION CONTROL

Part XIX

The F-A-R System of the Brooke Engineering Co.

EVEN THOUGH great advances have been made in combustion control practice, standardization can take place only to a limited extent because after all it is but auxiliary equipment and must be made to meet the physical and operating demands of the major equipment which it controls. These needs have been met in a variety of ways by different manufacturers. The Brooke Engineering Co., Inc., use low pressure variable master air loading pressure to transmit load indications to various boilers from a central point and then use electric operators to move the necessary dampers and valves. This allows the control panels, control elements and operators to be located at the same or different points as dictated by convenience and practicability.

A diagrammatic arrangement of the Brooke F-A-R control to one of a number of stoker fired boilers is shown by Fig. 1. As in other systems, changes in header pressure are taken as an indication of the steam load and these pressure changes actuate a master regulator as explained in Fig. 2, to move a damper in the discharge duct of a small fan. This fan is driven at constant speed and develops, with the damper closed, a maximum pressure of 1½ in. of water. The master loading pressure is taken from the duct just inside the damper so that the loading pressure varies from a maximum of about 1½ in., with the damper closed at full load, to almost atmospheric pressure with the damper open at no load.

This master loading pressure, indicated at all times by a gage on the control board, is piped to the air flow controller on each boiler. These controllers, shown by Fig. 4, move a damper in the forced draft fan duct and thus control the flow of air in accordance with the steam load, or master loading pressure.

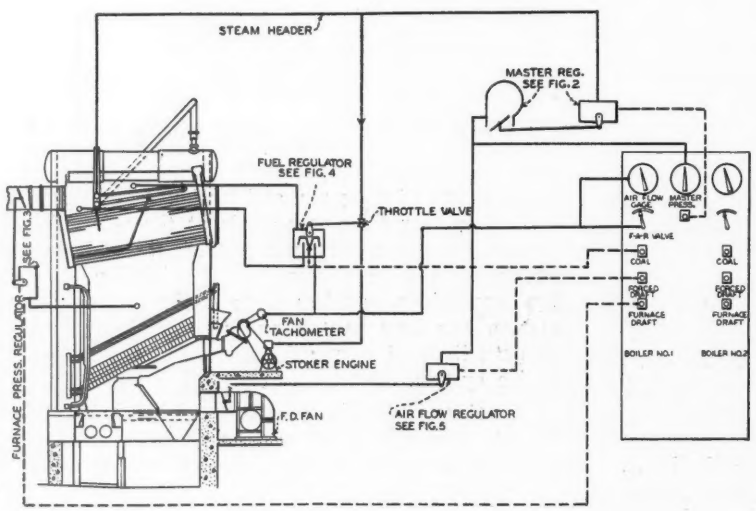


Fig. 1. The Brooke Fuel-Air-Ratio system as applied to a stoker fired boiler

Variations in steam header pressure act on the master regulator (shown by Fig. 2) and change the master loading pressure by moving a damper in the discharge duct of a small constant speed blower. The master loading pressure ranges from zero at no load to 1½ in. of water at full load and actuates the air flow controllers (shown by Fig. 4) of all boilers so as to supply air in proportion to the loading pressure.

Changes in air flow are reflected in the pressure drop across the boiler and this differential, effective on one side of the fuel controller (shown by Fig. 6) is balanced against the discharge pressure of a small tachometer blower driven proportionate to the stoker speed. Both of these pressures are proportional to the square of the boiler load and the fuel feed is therefore directly proportional to the air flow. The fuel-air ratio is adjustable from the boiler panel by means of the F-A-R control valve, which is simply a leak off valve which reduces the effective pressure of the stoker tachometer pressure. Both the master loading pressure and the tachometer pressure is indicated by gages on the control board. Furnace draft is under the control of an independent controller as shown, operating a damper in the boiler outlet.

Manual operation is provided by means of push buttons which act directly on the individual controls, or, the entire plant may be put under manual control from the master push button.

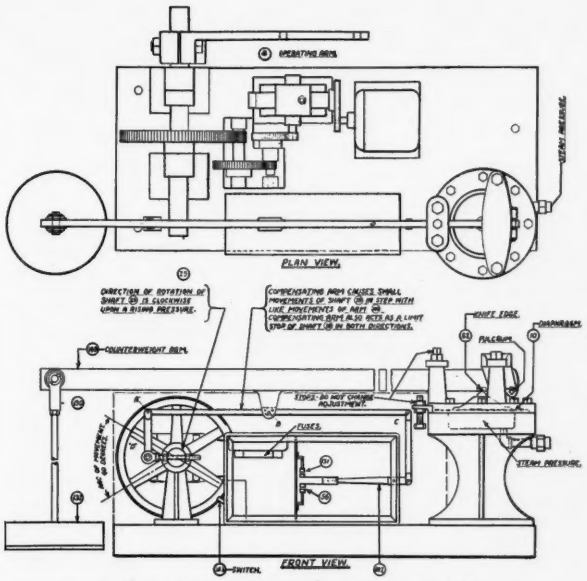


Fig. 2. The master steam pressure regulator

Steam pressure effective under diaphragm 10 acts through knife edge 62 on arm 149 counter balanced by weight 132. Upon an increase in steam pressure, indicating a drop in load, the arm moves upward carrying with it the movable pivot B and by means of the interconnecting linkage moves the left hand end of switch arm 142 downward to close the contacts 56.

This energizes the motor which operates to move shaft 29 clockwise and through operating arm 4, a damper. At the same time shaft 29 rotating moves pivot D and the compensating arm upward to break the electrical contact at 56 and stop the motor. Upon a drop in steam pressure arm 142 moves upward to make contact at 131 and turn shaft 29 counterclockwise.

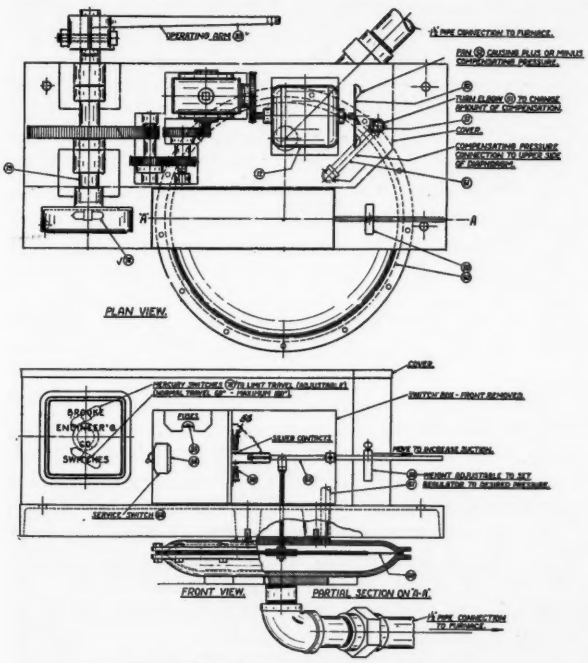


Fig. 3. The furnace pressure regulator

Pressure is piped to the diaphragm 60 and moves switch arm 62 to make contact at the top or bottom contact, 56 or 58, to energize electric motor 12 and operate the damper in the desired direction. The normal furnace pressure maintained by the regulator may be changed by shifting weight 50.

The motor carries a small fan 52, which, through pipe 61, puts a plus or minus (depending upon the direction of rotation) compensating pressure on the top of diaphragm 60 to prevent overtravel. The compensating effect may be adjusted by turning elbow 51. The arrangement of the fan and diaphragm is also shown by Fig. 4.

Shaft 29 rotated by the motor carries on one end an operating lever 59 to move the damper and on the other end two mercury limit switches 72. When a combination of damper and variable speed fan is used (additional) switches energize a motorized drive as shown by Fig. 5 to change the fan speed when the damper approaches the limit of travel.

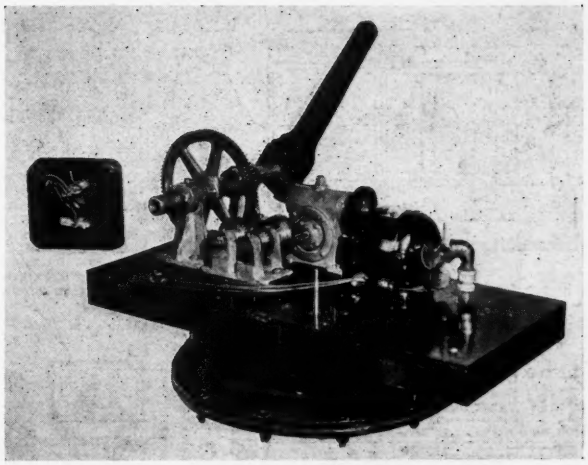


Fig. 4. The air flow regulator. This unit is similar in construction and operation to the furnace pressure regulator shown by Fig. 3 but has spring compensation so that the operating arm will assume a definite position for each value of master loading pressure. It is known as the Type J. S. F. regulator. The diaphragm is made large enough to be responsive to changes of 0.01 in. of water. The small motor drive shown above, and known as the Junior drive, is used where torque requirements are small. For larger torque requirements the Senior drive shown by Fig. 5 is used. Either drive may be supplied mounted either integral with or independent of the control element and contacts

Changed air flow through the boiler changes the draft loss and disturbs the balance of the fuel feed controller shown by Fig. 6. The unbalance closes electrical contacts to bring the coal feed in agreement with the air flow. The discharge pressure of a small blower driven from the stoker or stoker drive is used as a measure of the fuel feed and this pressure is piped to the opposite side of the double sealed bell to balance the draft loss. As these pressures vary as the square of the air flow and fuel flow respectively, the desired fuel-air ratio is maintained over the entire load range of the boiler, although the ratio may be changed at any time from the control board.

To prevent overtravel, the air flow controller is equipped with a small fan driven by a motor wired in parallel with the main operating motor. This compensating pressure, which may be positive or negative depending upon the direction of rotation of the fan, acts on top of the sealed bell and assists the tachometer

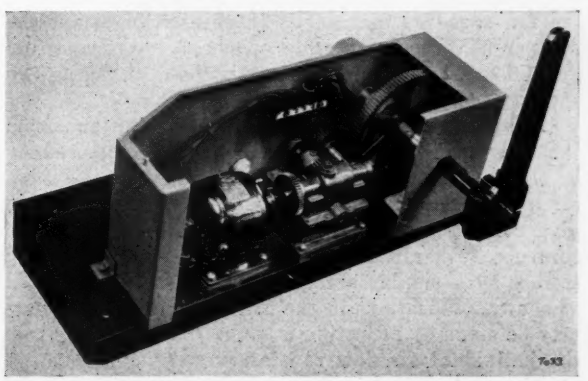


Fig. 5. A typical geared motor operator. This unit may be located at the control as in the master shown by Fig. 2 or may be located at any convenient point and connected to the control element only by an electrical circuit

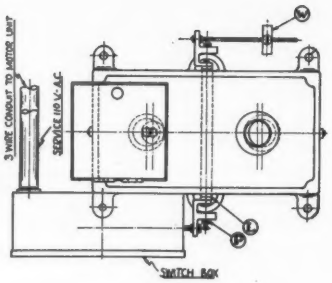
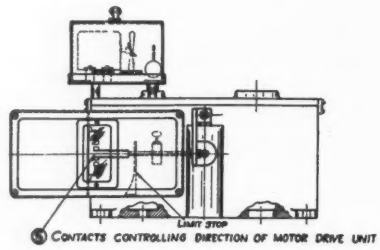
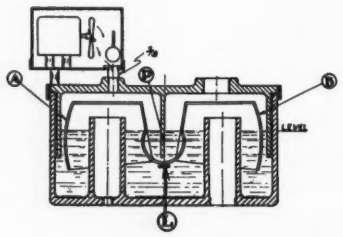


Fig. 6. The fuel regulator

This unit consists of two sealed bells connected together by pivoted shaft L. The draft loss across the boiler is effective on the right hand bell and the discharge of a tachometer blower under the left hand bell. Upon a change of air flow through the boiler, as a result of the action of the master, the draft loss differential will change, the balance of the fuel controller will be disturbed and one side of switch S will close to energize a motor driven unit shown by Fig. 4 to move a valve in the steam line to the stoker drive.

As the stoker speed changes, the tachometer pressure effective under the opposite side of the bell changes correspondingly and when balance is again established contact S is opened to stop the motor. To prevent overtravel a fan, driven by a motor wired in parallel with the operating motor, provides a plus or minus compensating pressure on top of the left hand bell. This compensating pressure acts with the tachometer pressure to break the contact sooner than would otherwise take place in order to allow for the lag in fuel flow.





pressure in breaking the electrical contact to stop the motors. If the change has not been sufficient to again balance the bell, contact is again made and the cycle is repeated.

Duration of motor operation depends upon the magnitude of the load change. The greater the load change the greater the unbalance and the harder the contacts are forced together and the compensating fan will not be able to separate them until the tachometer pressure reaches a value to give material assistance.

Furnace pressure is maintained by an independent regulator, shown by Fig. 3, which moves an induced draft fan damper. A compensating fan is also provided in this unit. Due to the lag imposed by fan inertia, direct control of fan speed by the regulator is not recommended by this manufacturer but if variable fan speed is desired a combination of damper and speed control is suggested.

In this case the regulator controls the damper as before and mercury limit switches prevent overtravel. A second set of mercury switches are set so that when the damper reaches the limit of its effective travel, one of the switches will close to increase or decrease the fan speed as necessary. In this arrangement the damper floats between wide open and closed position and takes all small fluctuations without changing fan speed.

Manual control is provided by push buttons from the central control panel. Master loading pressure may be changed from a switch which disconnects the regular master contacts and connects the push buttons to give control over all boilers in parallel. Individual controls, fuel, air and furnace pressure may be controlled by a similar arrangement on the boiler panel as shown. Variations in the rating of different boilers may be made by adjusting a counterbalance weight on the individual air flow regulators.

The fuel-air ratio of any boiler may be changed from the boiler panel by the F-A-R valve as indicated. This valve is a bleed valve in the tachometer discharge line. Increasing the leakoff reduces the effective pressure under the bell and increases the proportion of fuel to air because the stoker has to operate faster to balance a given draft loss through the boiler.

Oil Engine Costs

THIS YEAR'S REPORT on oil engine power costs for 1935 tabulated by the Subcommittee on Oil Engine Power Costs of the A.S.M.E. under the chairmanship of H. C. Major, Commissioner of Public Utilities, Rockville Center, L. I., N. Y., includes information from 168 oil engine generating plants containing 447 engines with a total rated horsepower of 237,755.5. The total net output of these plants during the past year amounted to 308,008,237 kw-hr.

Production costs, as covered in the report, are defined consist of: fuel cost; lubricating oil cost; cost of attendance and superintendence; cost of supplies and miscellaneous; cost of engine and plant repairs. Unit costs were calculated on the basis of net kilowatt hours, found by subtracting the power used for plant auxiliaries and station lights from the total gross output of the plant.

Figures given for power output per gallon of fuel oil and lubricating oil were calculated on the basis of gross output of individual units and plants. Lubricating oil economies of 111 plants generating 95 per cent or more of their output by means of full Diesel units are shown graphically in Fig. 1 with the kilowatt output per gallon of lubricating oil plotted against the running plant capacity factor. Fuel oil economies of the same plants are shown graphically in Fig. 2.

Running plant capacity factor, expressed as a per cent, is defined as the plant output in gross kilowatt hours times 100 divided by the total rated kilowatt hours of the individual units.

Total production costs for 167 of the plants for one year (plus or minus one month) are shown graphically on logarithmic coördinates in Fig. 3. In this chart total production cost in mills per net kilowatt hour is plotted against the specific output or the output in net kilowatt hours per year per kilowatt of installed capacity.

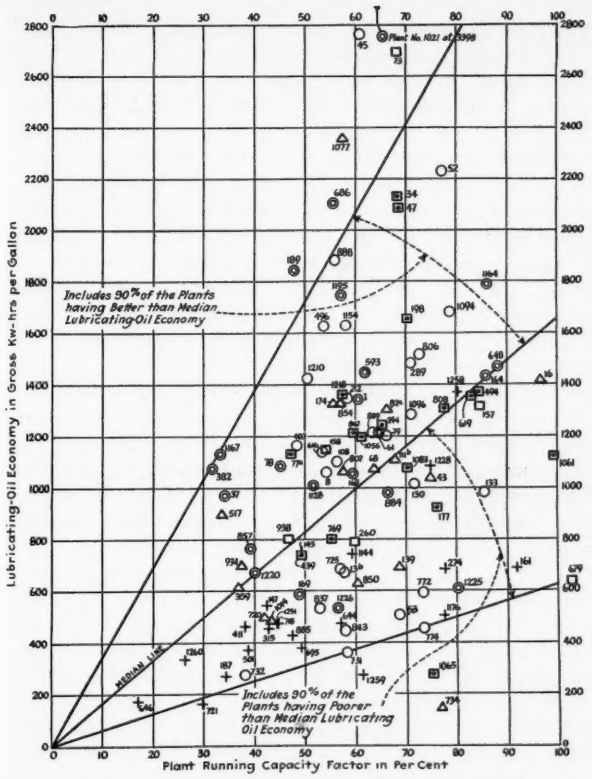

Lubricating-Oil Economy in Gross Kw-hrs per Gallon
Plant Running Capacity Factor in Per Cent
Includes 90% of the Plants having Better than Median Lubricating-Oil Economy
MEDIAN LINE
Includes 90% of the Plants having Poorer than Median Lubricating Oil Economy

Fig. 1. Lubricating oil economies of 111 full Diesel plants. (For key symbols refer to Fig. 2)

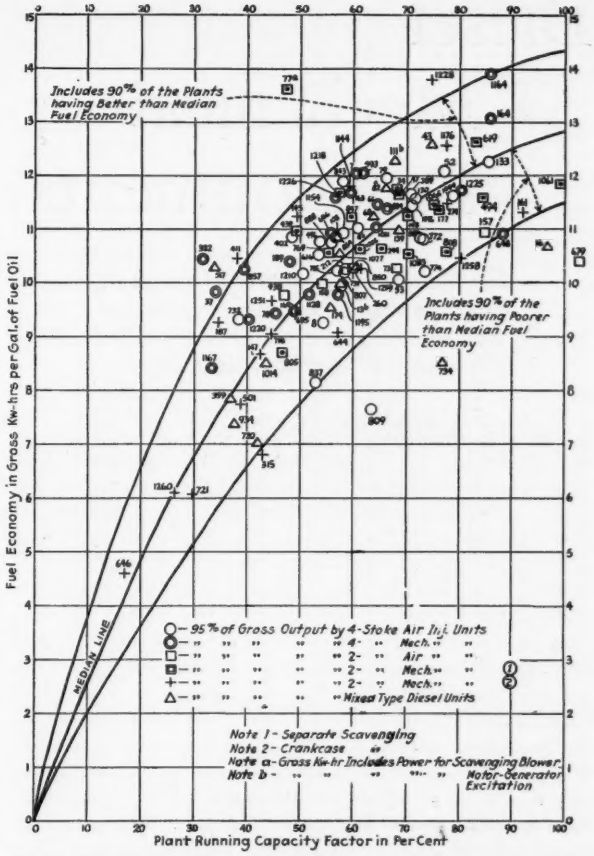

Fuel Economy in Gross Kw-hrs per Gal. of Fuel Oil
Plant Running Capacity Factor in Per Cent
Includes 90% of the Plants having Better than Median Fuel Economy
Includes 90% of the Plants having Poorer than Median Fuel Economy
MEDIAN LINE
95% of Gross Output by 4-Stoke Air Inj. Units
Mixed Type Diesel Units
Note 1 - Separate Scavenging
Note 2 - Crankcase
Note a - Gross Kw-hr Includes Power for Scavenging Blower
Note b - Motor-Generator Excitation

Fig. 2. Fuel economies of 111 full Diesel plants (not corrected for fuel heat content or altitude)

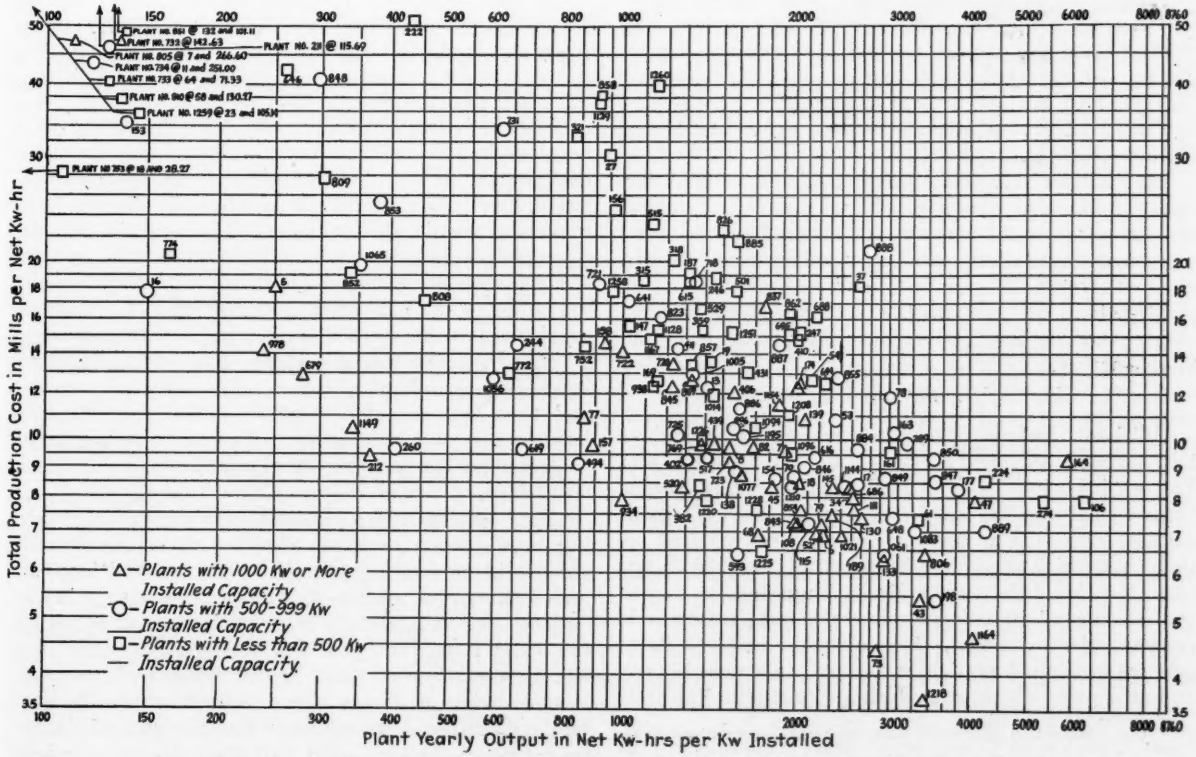

Total Production Cost in Mills per Net Kw-hr
Plant Yearly Output in Net Kw-hrs per Kw Installed
Plants with 1000 Kw or More Installed Capacity
Plants with 500-999 Kw Installed Capacity
Plants with Less than 500 Kw Installed Capacity

Fig. 3. Total production costs for 167 plants included in the 1935 A.S.M.E. oil engine power cost report

Diesel Mechanical Developments

Large units of over 2000 b.hp. show trend toward standardized practice. Fuel economy 13.5 to 14 net kw. hr. per gal. By Max Rotter*

LARGE DIESEL ENGINES as a designation is somewhat elastic but may be taken as engines of 2000 b.hp. and over as this is about the capacity above which there is a marked reduction in the number of Diesel builders. The depression hit the large Diesel at least as hard as any other line of heavy machinery; nevertheless, during that period was built the largest Diesel power plant in the country, the 25,000 kw. station of the City of Vernon, California, with five 7000 b.hp. Hamilton, Man., two-cycle double-acting mechanical injection engines; and during that period, also, has taken place the major transition from air-injection to mechanical-injection for large engines. An analysis of 180 large Diesels, aggregating over 730,000 b.hp. which are now under construction shows that: 48, aggregating 150,000 b.hp. are four-cycle single-acting, ranging from 2000 to 4500 b.hp.; 77, aggregating 280,000 b.hp. are two-cycle single-acting, ranging from 2000 to 8000 b.hp. and including 15 opposed-piston type; and 55, aggregating 300,000 b.hp., are two-cycle double-acting, ranging from 3000 to 14,000 b.hp. As between four-cycle and two-cycle, 48 engines, aggregating 150,000 b.hp. are four-cycle, and 96, aggregating 310,000 b.hp. are two-cycle, almost exactly two to one in favor of the latter. The four-cycle double-acting has disappeared entirely.

As between single-acting and double-acting, and not considering capacities above the range of the former, or below the range of the latter, 70 of these engines are single-acting, and 51, double-acting. It is a choice between the simplicity and accessibility of the single-acting, as against the smaller space requirements and silghtly lower fuel consumption of the double-acting.

Air vs. Mechanical Injection

Without exception these 180 modern large engines have direct mechanical fuel injection. Not one of them has air-injection, which until comparatively recent times was almost universal for large Diesels. Mechanical injection still requires a higher grade of fuel oil than that which can be used successfully with air-injection; but this difference is diminishing, and the larger the mechanical injection engine, the less fastidious it becomes about its fuel. The question resolves itself into the continued availability of the higher grade fuel, and at a price which, considering also the higher first-cost and maintenance expense of the air-injection engine, enables the lower operating expense of mechanical-injection to offset the higher unit price of its fuel. Apparently the purchasers of large Diesels are unanimously confident that this condition will continue; with the added prospect that means will be perfected to use lower grades of fuel with mechanical injection.

During recent years the main changes that have been made in the general design of larger Diesels, other than such as were necessary for the transition from air to mechanical injection, have consisted in the selection of the simplest and most reliable of the elements perfected in earlier constructions, and the extension into larger sizes of designs that had been proved successful in smaller.

In the case of large Diesels, mechanical fuel injection has resolved itself into direct injection; that is, the spraying of the fuel directly into the combustion space in the cylinder, by means of a pump plunger. The pump is under control of the engine speed governor, measuring the delivered fuel according to the engine load. The delivery pressure ranges from 4000 to 8000 lb., and the pump plungers must not leak under this, or the governing will become erratic. Refinements in manufacture have made possible the entire elimination of packed glands for the plungers, thus avoiding the necessity for adjustments to prevent leaks, and the consequent changes in plunger friction which react upon the governor. The pump plungers, which are operated by cams, are invariably of very hard-surfaced material, the barrels in which they work with practically no clearance, are either of a special very fine-grained cast iron, or of hard-surfaced steel.

The use of a separate pump, that is cam, plunger, barrel, and valves, for each combustion space has become universal. Sometimes each individual pump is mounted on or close to the particular cylinder it serves; sometimes the pumps are combined into a single aggregate.

Fuel Valve

The fuel valve, also, is gradually becoming conventionalized. Unlike the fuel valve of the air-injection engine, which must be mechanically operated and timed, the fuel valve of the mechanical injection engine is a simple spring-loaded valve, opened by the pressure of its own fuel, and closed by the spring. Modern developments have been towards reducing the valve lift to the minimum, and making the closing as nearly as possible instantaneous, to prevent dribbling, which is the last portion of the fuel of an injection leaving the nozzle at a pressure too low for spraying, and thus hanging on the nozzle, being cracked, and leaving carbon on the nozzle. It has become general to provide a fine strainer for the fuel oil, close to each fuel valve.

Fuel nozzles of large Diesels are also gradually taking on a similarity; being provided with a number of spray orifices, ranging from 15 to 35 thousandths of an inch in diameter, arranged to deliver the sprays in the desired direction. Small as it is, this nozzle is one of the most important parts of the engine. It is not merely a number of holes drilled into an oil passage. Besides being of proper size, the orifices must be correctly directioned, round, and smooth, with their entrance edges well rounded and their discharge edges

*Vice-president in charge of Engineering, Busch-Sulzer Bros. Diesel Engine Co., St. Louis. From a paper delivered before the Midwest Engineering Power Conference in Chicago.

sharp and clean; otherwise the performance of the engine will suffer. It is only in comparatively recent years that such pieces can be produced commercially. More and more care is taken that the fuel nozzles shall be effectively cooled.

With direct injection, the shape of the combustion space in the cylinder becomes increasingly important. Two general types have been developed. In the first the fuel jet is short, and impinges on the piston top before the atomizing is complete, the atomizing being partly accomplished by this impact. In the second the fuel jet is long, and such impinging carefully prevented. The first type is more generally used, and ordinarily is approximately lens shaped, the axial depth of the space being greatest at the center. The second is exemplified by the Hesselman patent. In this type, the transverse section of the space conforms to the shape of the fully atomized fuel jet, the axial depth being smallest near the center, where the fuel nozzle is located. The space is of such dimensions that the spreading jet will not, while still in liquid form, touch metallic surfaces at any point.

Scavenging

For large two-cycle engines, port exhausting and port scavenging have become by far the most general; although not universal. As an exception, the large Burmeister and Wain two-cycle engine scavenges through ports; but exhausts through a piston valve controlled passage in the head; the valve, serving also as an auxiliary power piston. Opposed-piston engines, like Sun-Doxford, have their scavenging ports at one end of the cylinder and their exhaust ports at the other end. The common arrangement is to locate the scavenging and exhaust ports in the same part of the cylinder.

Scavenging and exhausting have been accorded more inventive attention than almost anything else about a two-cycle engine. I have already collected nearly seventy U. S. patents relating to this phase. Many of these go so far as to include in their claims, as well as in their specifications, a description of the exact course of the air through the cylinder. Considering the fact that the streams are not parallel, and that in the cylinder of an engine running at 150 r.p.m. the entire process of exhausting and scavenging is performed in about 0.1 sec., while the port openings change from zero area to full and back to zero, this looks like a fertile field for argument. The timing and duration of exhausting and scavening are, of course, definite in each construction. Each of the American builders of large Diesels uses a different scheme.

Scavenging air, at a pressure of 1½ to 2½ lb., is furnished, in the case of moderate sized engines, by a reciprocating pump or rotary blower attached to the engine; and in the case of larger engines, by a rotary blower attached to or driven by the engine, by a centrifugal blower driven by an electric motor, or by a scavenging pump driven by an auxiliary Diesel engine. It is more and more becoming the greatly to be recommended practice to filter this air on its way to the blower, just as it is to centrifuge the fuel, for the purpose of reducing cylinder wear.

In all large Diesels the cylinders are fitted with removable cast iron liners. These are the only major parts of a Diesel that wear out. Modern developments, especially in metal composition and foundry practice, supplemented by clean air and fuel, have reduced the wear of the liners to less than one-half of what it was only a few years ago under equivalent conditions of operation. The liners are usually cast iron alloyed with nickel and chromium, and moderately hard, that is 200 to 240 Brinell. It has been demonstrated that hardness in itself does not indicate the wearing quality of large Diesel liners. The greatest wear is invariably near the combustion end, where the lubrication is poorest, and where the gas pressure behind the piston rings is greatest. These are the conditions that limit the useful life of a liner, and they exist equally in single-acting and double-acting cylinders, and in trunk-piston or crosshead engines.

Pistons of all large Diesels are cooled by circulating fresh water or oil through them. There is no uniformity in practice as to which cooling medium is used in the pistons. In double-acting Diesels the chief trouble, in their earlier examples, was breakage of piston rods. Near the pistons, the outsides of these rods were exposed to the heat of combustion, and the insides to the effect of hot water. In the beginning, lack of experience to guide the selection of material and its heat treatment, caused various methods to be adopted to shield the outside of the rod against the heat of combustion, and the inside against the corrosive effect of the water.

These shielding means naturally complicated the structure of the piston rod, adding tubular jackets on the outside, and additional tubes on the inside, which increased the cost of the engine, although they were otherwise not seriously objectionable. In later years more suitable materials have been adopted, and simpler means developed, making at least part of these complications unnecessary, and the rods are today as reliable as other parts of the engine. Piston-rod stuffing boxes, also, have been perfected, both in their tightness and their lubrication.

Supercharging

In their general structure large Diesels are approaching something like a conventional design; a bedplate forming a bottom girder, a cylinder block forming a top girder, frames between the bedplate and the cylinder block, and tie rods joining these parts into a structure of great strength and rigidty.

Supercharging, that is, charging the cylinder with a greater weight of air than would fill it without specific means for that purpose, the additional weight of air enabling the combustion of more fuel, and thus increasing the power output of the cylinder, has been applied to a number of large four-cycle engines, and in a few special cases to two-cycle. The construction and functioning of a four-cycle lend themselves far better to economical supercharging, than do those of a two-cycle. The method most generally used for supercharging large four-cycle engines is the Buechi system, in which the charging and supercharging air is compressed and delivered to the engine by a centrifugal blower driven by a turbine that uses the exhaust gases from the engine as its operating medium.

Fuel consumption of these large modern Diesels is such that they will deliver 13½ to 14 net kw. hr. per gal. of oil.

Oil Tank Connections and Piping*

The secret to reliable fuel oil supply is an adequate, well planned piping system. By James O. G. Gibbons

AS A GENERAL rule the connections to the tank consist of the following: Oil suction, oil return, steam and return for heating coil, fill connection, opening for measuring rod, oil gage line and vent line. In addition to these, in the case of large tanks, or where required, there should be a steam connection for smothering in case of fire. The tank should also be provided with a manhole, preferably 18 in. in diameter.

In the suction line from the tank, either a foot valve or a check valve will be required to prevent the return of oil back to the tank. Check valves immediately outside the tank are preferable to foot valves as it is found that if a valve with a nearly horizontal seat is used it will work in a satisfactory manner, and it is most desirable that as far as possible, nothing should be located inside the tank which may later require attention.

Oil suction and steam lines should be run together in such a way as to insure a temperature of about 100 deg. F. in the oil when it reaches the pumps. Lower temperatures may interfere with the free flow of the oil and appreciably higher temperatures will cause trouble through formation of gas. For this reason it is well to avoid as far as possible, vertical loops in suction lines which may act as gas accumulators.

Suction lines should be as short as possible, and when the tank is located some distance from the boiler house, it is generally better to build a small pump house and install the pumps near the tank.

Pipe Sizes

Sizes of tank connections are largely a matter of judgment. It is not much good wasting very much time on calculations involving viscosities because an adequate system, once installed will be expected to handle anything which may be bought during the next 20 yr. under the general classification of heavy fuel oil. At present such oil is either sold as "Bunker C" with a nominal gravity of 14-16 Baumé, or is classified as No. 6, but unless bought under strict specifications it may be almost anything that can be burned.

The following pipe sizes are more or less standard for installations up to several thousand horsepower.

Fill line and fill box, for road truck deliveries, 6 or 8 in., but 6 in. will be satisfactory if it is not desired to pay for an 8 in.

Fill line from railroad cars 4 in. with a 1 in. or 1¼ in. steam line for the heaters in the cars.

Vent line should be 2 in., unless the local authorities require something larger, for which there is no necessity.

For the measuring rod, a 2-in. pipe inside the tank will be quite satisfactory.

Steam and return lines of ¾-in. pipe for the heating coil will be ample, as the amount of steam required for heating should be small, and a ½-in. pipe will do for the smothering line unless the local authorities require a larger one.

The suction line must, of course, be carried down close to the bottom of the tank, and all other lines except the smothering and vent lines should be carried to the same depth. In some cases, special trapped fill connections are permitted, otherwise the fill line should be carried down in a similar manner.

This leaves only the oil suction and return lines to be decided upon. As we ought to get more than 3 hp.-hr. out of a gallon of oil, if we figure on pumping this amount, we shall have some over for maintaining a flow in the return line. On this basis we can estimate that we shall have to pump less than 6 gal. of oil per min. per 1000 hp., and with 3000 hp. we should have to handle less than 20 gal. per min.

This being the case, it is seldom necessary to make the suction line more than 2½ in. dia., so it may be said that with reasonable size installations, the suction line will be 1½ in., 2 in., or 2½ in. and within this limited range it should be easy to choose a suitable size.

The discharge lines from the pump carrying the oil through the heaters to the burners need seldom be more than 1½ or 2 in. In the case of steam atomizing burners where the oil is pumped against only 15 or 20 lb. pressure, and the exhaust from the pumps can be used for heating the oil, the cost of pumping is negligible, and pipe friction is not of much importance, but with mechanical burners, and heaters using live steam, more consideration may be given to the friction losses in the oil piping, especially in large installations.

There is really no advantage in installing large return lines, as, in order to maintain the necessary head at the burners, an artificial resistance has to be introduced by a relief valve, and a certain amount of resistance on the other side of the valve is not important. Generally a 1¼-in. return line will be satisfactory or at most a 1½-in. line.

It should be kept in mind that with installations having a wide range of load, it is well to keep the oil lines reasonably small so as to maintain a satisfactory rate of flow at light loads.

In view of the unknown qualities of the oil which may be used in the future, and possible changes in load conditions, judgment based upon experience and common sense should always be combined with the results of calculations based upon purely arbitrary assumptions.

Fittings for oil lines should be malleable iron, and for mechanical burners operating under high pressure should be of extra heavy pattern.

A cracked fitting in a suction line may give a great deal of trouble and is sometimes extremely difficult to discover, and hot oil is a very dangerous thing. If a man is hit with a discharge from a broken fitting the results may be serious.

*All rights reserved by author.

Great care should be taken to prevent leaks in hot oil lines, especially when they are run overhead, as even one drop may cause a bad burn.

Steam lines will of course be installed in accordance with standard steam practice, and both live steam and oil lines should be covered to prevent loss of heat. In connection with this it is well to remember that the specific heat of oil is only about 0.50 and the velocity of the flow in the mains is sometimes very slow, so there is a great tendency to lose temperature, which may prove to be an important point where the heaters are installed some distance from the burners, in fact, in some cases where the main heaters are installed a long way from the boilers it may be advisable to install a booster heater nearer to them, especially in the case of mechanical burners where the temperature of the oil is more important than it is with steam atomizing burners.

Sometimes two suction lines are installed, one terminating 2 or 3 inches from the bottom of the oil tank, and the other higher up. When this is done it is possible to pump out water and sludge through the low suction while oil for the burners is supplied through the high suction.

Parallel Operation of Compressors

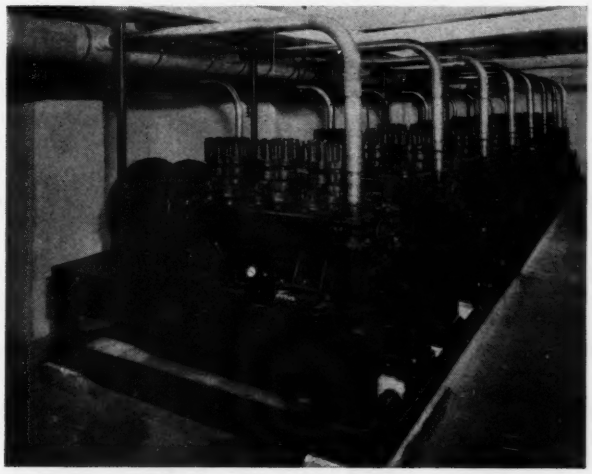
Hale Bros. Department Store, Sacramento, Calif., uses eight compressor units for all year air conditioning installation

LAST YEAR Hale Bros. of Sacramento, Calif., modernized their three floor department store and included air conditioning as part of the program. The installation is interesting in that interruptions were not made in normal store operation and the equipment was installed without special foundations and without sacrificing valuable floor space.

Twenty-four air conditioning units are installed, nine on the first and third floors and six on the second floor. They are designed for cooling and dehumidification in summer, heating and humidifying in winter, cleaning and circulating throughout the year. The units are piped in groups of three and are individually controlled with Alco magnetic valves with a Henry valve on either side to permit servicing without pumping down the entire system.

Refrigeration capacity of the system is approximately 160 t., divided between eight Westinghouse units located in a vault under the sidewalk and piped for parallel operation. Compressors are driven by 208 v., 3 phase, 60 cycle motors. The suction header. visible in the photograph is a 6 in. line insulated with Johns-Manville covering to prevent condensation and dripping. This insulation is extended to all suction lines from all of the air conditioning units. The 5 in. high side header is not insulated nor is the oil equalizer header as shown in the photograph. Copper pipe with sweat type joints was used, wherever possible. All steel pipe used was welded.

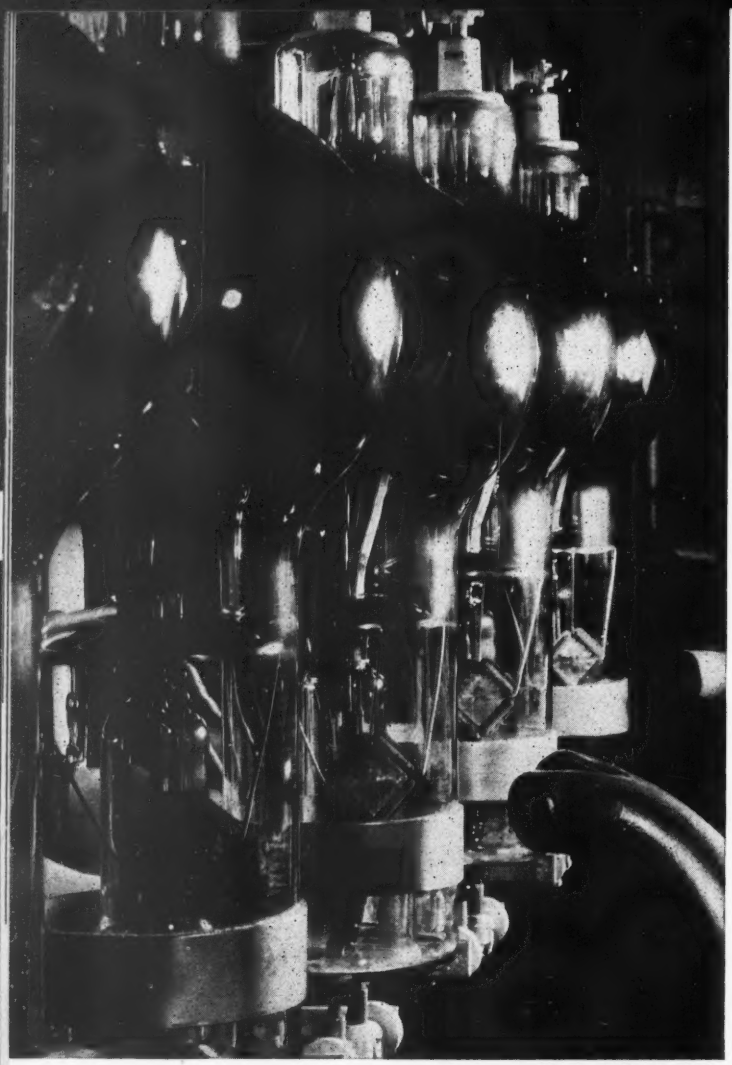
Two Gay water cooled condensers connected in parallel are installed in the roof of the building with a liquid receiver underneath. Condenser water is cooled in a spray pond using ten Binks spray heads on 10 ft. centers in two rows 20 ft. apart. The 750 g.p.m. circulating water pump located on the third floor takes the water from the 1200 gal. sump and pumps through the two condensers to the spray heads. The tank level is maintained constant by a float control. Average water conditions range from 70 to 80 deg. F. with a maximum obtained under 96 deg. dry bulb and 79 deg. wet bulb temperature within 90 deg.



Eight Westinghouse units operating in parallel under automatic control. The insulated suction header is shown in the upper left with the uninsulated discharge header immediately below. The oil equalization header is shown in the lower right hand corner

Cooling units are individually controlled from thermostat and control panels while the compressor units are cut in and out automatically in accordance with the load demands. A pressure potentiometer located on the suction manifold determines the setting of a multi-step controller which opens and closes contacts to start and stop condensing units. As the suction pressure increases, the pressure potentiometer and multistep controller advance their positions to bring more compressors into operation. As the suction pressure decreases, these operate to reduce the number of units operating.

Sufficient time delay is provided in the multistep controller to insure machines starting and stopping only in response to steady load charge. Range and limits of the potentiometer may be adjusted to meet the requirements. For instance, at 35 lb. suction pressure only one compressor will operate but as suction pressure increases additional units will start until all are operating at 42 lb. pressure. A control relay, located between the potentiometer and the multistep controller, automatically returns the controller to the initial starting position in the event of power failure so as to prevent a number of machines restarting simultaneously when power is restored. Ten-point selector switches are provided so that the sequence of compressor operation may be varied periodically so as to equalize the service of each unit.



Margaret Bourke-White

Electron Tubes

Part VIII—Further consideration of the gas-filled three element tube. The control function of the grid. Fundamental principles involved in the control of the "firing" potential by means of the grid potential

By A. W. KRAMER

AS WAS SHOWN IN OUR consideration of the action of the gaseous triode in the preceding article, this type of electron tube is, fundamentally, a relay; it cannot be used as an amplifier as can the high-vacuum triode.

Since the function of a relay in an electrical circuit is a relatively simple one, one may wonder why it is that the gaseous triode has become such an important device in the field of electronics. It will be the purpose in the next several chapters to answer this question to some extent at least and to indicate the manner in which it is used in electrical circuits.

In ascribing the function of relaying to the gaseous triode, it must be understood, of course, that this tube like its two element relative, is also a rectifier. This should be clear from our study of the tube. In the two element tube, the plate current flows whenever the plate is positive with respect to the cathode, but not when the polarity of the plate is reversed. In the three element tube this also is the case but in addition a variable control element in the form of a grid is introduced, which allows current to flow during the positive half of the cycle only when the grid permits it. In this type of tube, even when the plate is positive, no current flows *unless* the grid permits it.

This controlling property of the grid is extremely useful in that it enables the start of the positive half cycle of the alternating current to be delayed as long as desired.

The way in which this is accomplished will now be described in detail. Consider, for example, the circuit shown in Fig. 1. This, it will be noted, consists of a 500 v. alternator supplying current to a circuit containing a gaseous triode and a load resistance, R. A grid battery is also provided so that a certain negative grid potential can be impressed on the grid. A switch is provided so that the grid potential can be cut in or out and a switching arrangement is provided so that the number of cells connected to the grid can be increased or decreased.

With the grid battery switch open as shown in Fig. 1 there is, of course, no potential whatever on the grid and the tube acts exactly as a two element gaseous tube, that is, purely as a rectifier. Under these conditions the negative half of the alternating current wave will, of course, be suppressed and current will flow only during the upper or positive half of the cycle, as shown at B.

Suppose, however, that the grid battery switch is closed as shown in Fig. 2 impressing the full grid battery negative potential on the grid. If this negative potential is high enough, as it will be assumed to be here, it will effectively block all current through the tube and no current will flow in the load circuit.

Now, let us assume that the grid potential is lowered somewhat by cutting out some of the cells of the battery as shown in Fig. 3. In this case no current will flow during the positive half cycle until the plate voltage has reached a certain definite value—a value of

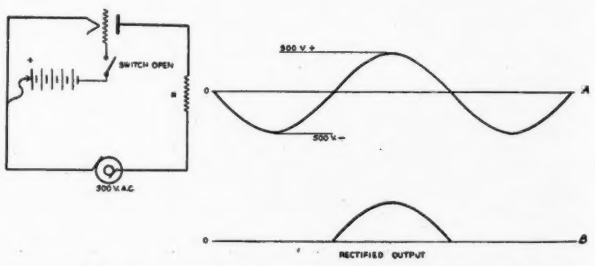


Fig. 1. With no potential on the grid, this 3 element tube functions merely as a rectifier

course, which depends upon the grid potential. Here, this value will be assumed to be just under 500 v., say 480. The result is quite obvious. The positive half wave will be chopped off as shown in Fig. 3. The current rises instantly to a value of 480 v. and thereafter follows the sine wave variations of the remaining portion of the half cycle in the usual way.

By still further reducing the negative grid potential by cutting out additional cells as shown in Fig. 4, the "firing point" of the tube as it is called is still further reduced and the tube will become conducting at a still lower plate potential. As a consequence current will begin to flow earlier during the positive half cycle as indicated at B, Fig. 4.

In the foregoing illustrations (examples 1-4) the start of the discharge through the tube is entirely dependent upon the steady value of negative potential impressed on the grid. Since in every half cycle of an alterating current wave, the same values of potential are passed through twice—once when the current is increasing from zero to maximum and again when

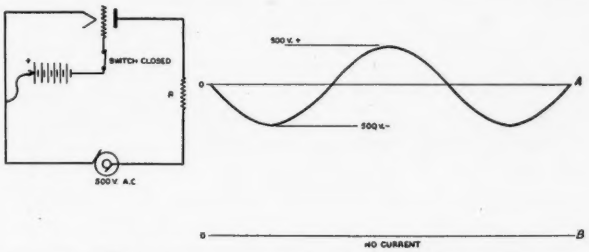


Fig. 2. When a high negative potential is applied to the grid, as in this case, no current flows through the tube

decreasing from maximum to zero, as shown in Fig. 5—it is evident that this simple method of control cannot cut off more than half of the positive cycle. That is, the wave can be chopped off like this

or like this

or this

but not like this

If it is desired to chop the wave off as in the last diagram, a time element will have to be introduced in the application or removal of the grid potential. If, for example, a high grid potential is maintained over a large portion of the positive half cycle and then suddenly removed as shown in Fig. 6, the plate current will flow only during a small portion of the latter half of the half cycle—shown by the shaded area.

Thus it is evident that by properly applying the grid potential, the three-element gaseous tube can be set to chop off and use any portion of the rectified wave as shown in Fig. 7.

So far, only single half cycles have been considered but it must be understood that this control of the current by the grid is repeated during successive half

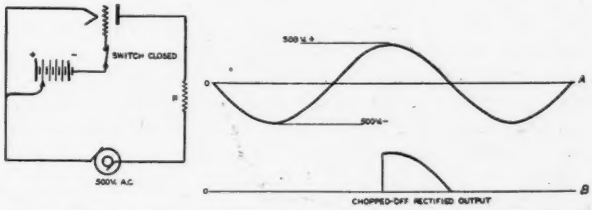


Fig. 3. With a moderate negative grid potential part of the rectified output is chopped off as shown

cycles of the alternating current wave as depicted at B and C in Fig. 8.

The exact manner in which this is accomplished will be described later but first it will be of advantage to consider, briefly, what happens at that part of the cycle where the voltage passes through zero, i.e., at the point where the discharge through the tube stops.

As was shown in the preceding chapter[1] the reason the grid loses control of the plate current once the plate current is established is because of the presence of a large number of positive ions in the space between the cathode and the anode. These ions neutralize the negative space charge.

Ionization and Deionization Times

As the anode voltage decreases, the production of these ions decreases and finally there comes a time when the rate of ion generation can no longer be maintained and the arc (for the discharge through the tube is really an arc) stops. At this instant, the positive ions combine with the nearby existing free electrons to form neutral atoms of whatever gas may be present in the tube. The grid can regain control of the tube just as soon as the positive ions have been removed from the space around the grid. The length of time required for these ions to be removed (i.e., for their recombination with electrons to form neutral atoms) and for the grid to regain control is called the "deionization time." This time varies from about ten to several hundred microseconds. This time varies directly with the gas pressure and inversely with the negative grid and anode voltage.

The formation of the arc discharge also requires a definite length of time, called the "ionization time." This is the length of time required for the ions to

[1]Part VII, page 472 August issue.

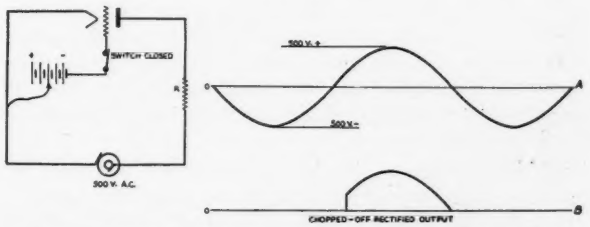


Fig. 4. Here a still lower negative grid potential is used

reach all parts of the discharge path. The ionization time is usually very much smaller than the deionization time but decreases with an increase in voltage or gas pressure.

The ionization and deionization times are important in the application of tubes for various frequencies since they impose limiting conditions with respect to the use of the tube on higher frequencies. For the present, however, we can ignore these limiting factors and assume that the grid regains control whenever the anode voltage passes through zero. A condition can easily be imagined, of course, in which the frequency is so

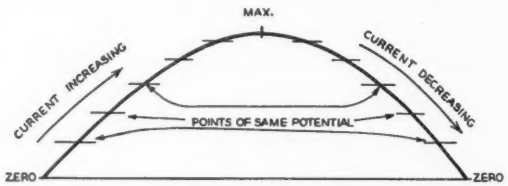


Fig. 5. During each half wave, the same values of potential are passed through, twice

high that deionization can not take place between successive positive half cycles and under this condition the tube would be useless, either as a rectifier or for other control purposes.

For our purpose here it will be sufficient to keep in mind merely the "starting" voltage and assume that the "extinction" voltage is somewhere close to zero. In the two-element gaseous tube, the starting voltage and the extinction voltage are nearly the same. In the three-element tube, however, they are not the same;—the Thyratron tube owes its great versatility to the grid's ability to make the starting voltage vastly greater than the extinction voltage.

Another point. In our consideration of the tube here the grid has been operated under a negative poten-

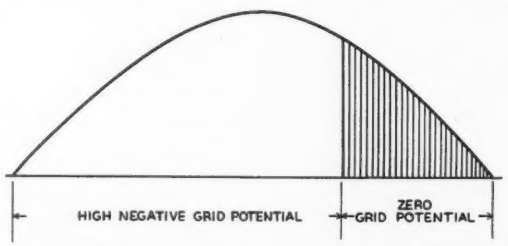


Fig. 6. Showing how the removal of a high negative grid potential can initiate the conducting period at any time desired

tial. As has been mentioned before, however, this is not an essential requirement and tubes may be divided roughly into two classes according to their characteristics. One class includes the so-called "positive tubes." In these the discharge will *not* start until the grid has been made positive with respect to the cathode. The other class contains the "negative tubes" which are designed so that the discharge *will* start *unless* the grid is maintained a definite amount negative with respect to the cathode.

These differences in characteristics are obtained by varying the construction and spacing of the elements in the tube. The characteristics displayed by the positive-grid type of tube are obtained by making the shielding

Fig. 7. By properly applying the grid potential, the three element gaseous tube can be used to "chop off" and use any portion of the rectified wave as shown here

due to the grid so effective that the plate voltage has practically no effect on the potential in the neighborhood of the cathode. The electron current leaving the cathode is, therefore, independent of the plate voltage. In the negative grid tubes, the shielding is not as effective and the electron current leaving the cathode is not independent of the plate voltage.

So much for the fundamental action of the tube. If in the foregoing account we have rambled a little and at times repeated ourselves, perhaps we may be excused on the plea of our desire to leave no room for doubt. If the fundamentals are understood the applications will seem easier. Now, let us recapitulate a little, to see how far we have come.

To begin with, we have the two-element gaseous tube. This tube is fundamentally a rectifier—it passes current when the plate is positive and suppresses it when the plate is negative.

The three element tube also is a rectifier but in this case the rectified current is subject to further control

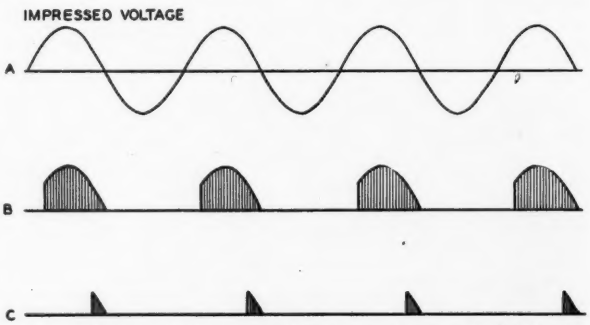


Fig. 8. Diagram showing control action upon successive half cycles

by means of a small grid potential (negative or positive, but in practice usually negative). Because of the action of the grid, the rectified half cycle can be "chopped off" at any point between 0 and 180 deg. As a consequence of this action, it is evident that the average current through the tube can be controlled to any desired degree between zero and maximum.

As has already been mentioned, the sensitivity of the grid controlled gaseous discharge tube is extremely high. A tube which will deliver 2.5 amp. at 1000 v. can be controlled by a grid current of 0.005 micro-amperes.

In the examples shown in Fig. 7, the control only extends to the positive half cycles. This, of course, is the result of the tube's inherent property of rectification. Complete control can be obtained, however, by the use of two tubes in the ordinary rectifier circuit for full wave rectification.[2]

In this chapter we have endeavored merely to expound the fundamental principles involved in the control function of the three element gaseous tube. Just how the controlling potential is applied to the grid at exactly the right time will be explained in a subsequent article.

[2]Fig. 11, p. 233, April 1936 issue.

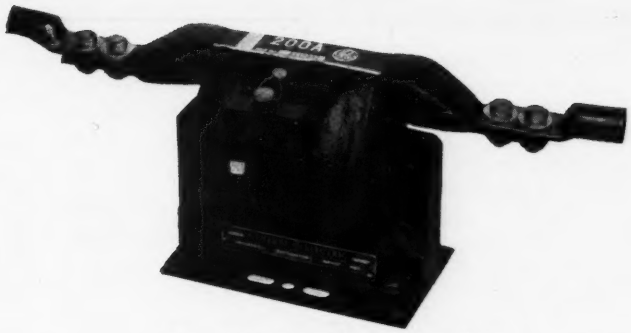


Fig. 1. Switchboard Current Transformer

INSTRUMENT TRANSFORMERS

By E. S. TOWNSEND

Meter Dept. General Electric Co.
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FUNDAMENTALLY, instrument transformers are no different from other types of transformers; they merely constitute a special class because they are designed for a specific purpose.

In general, instrument transformers can be divided into two kinds, current transformers and potential transformers. A current transformer (Fig. 1) serves to transform a current of high amperage to a current of low amperage. Likewise, a potential transformer (Fig. 2) serves to transform a high potential to a low potential. Hence, by the use of current transformers, it is possible to use meters with only a small, known fraction of the line current passing through them, and by the use of potential transformers it is necessary to apply only a small known fraction of the line voltage to the meter.

Potential Transformers

The design of the two electrical circuits of a transformer can be such that the potential received from the secondary terminals will bear a definite relation to the potential applied to the primary terminals. Such a transformer is known as a potential transformer. In service, a potential transformer has one primary terminal connected to each side of the line (see Fig. 3). With such a connection the full line potential is applied between the two primary terminals.

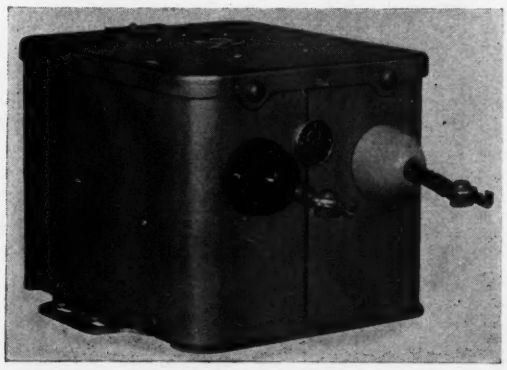


Fig. 2. Switchboard Potential Transformer

For example, if the line is 575 v., the potential between the primary terminals of the transformer would be 575 v., and since the transformer is designed to transform this voltage to a lower voltage, the potential between the secondary terminals would be only a fraction of the 575 v. Common practice has made the secondary voltage of most potential transformers 115 v., which—in this case—is one-fifth of the primary voltage. Hence the transformer will be described as having a ratio of 5 to 1, which is commonly expressed as ratio 5:1. A variation of the line voltage above or below the normal 575 v. will produce a proportional change in the secondary voltage, as the ratio of the transformer will always remain 5:1 and the secondary voltage will always be one-fifth of the primary voltage.

Another potential transformer designed for use on a 2300 v. line would have 2300 v. on the primary and 115 v. on the secondary. Since the secondary voltage is one-twentieth of the primary voltage, the transformer is described as having a ratio 20:1. Likewise a transformer for a 13,800 v. circuit would have a ratio 120:1, a transformer for 23,000 v. circuit a ratio of 200:1, etc. Most potential transformers have a 115 volt secondary, although other secondary voltages are sometimes used on special applications.

Obviously a potential transformer must be selected having a voltage rating the same as the normal voltage of the line on which it is to be used. Most manufacturers of potential transformers list transformers in

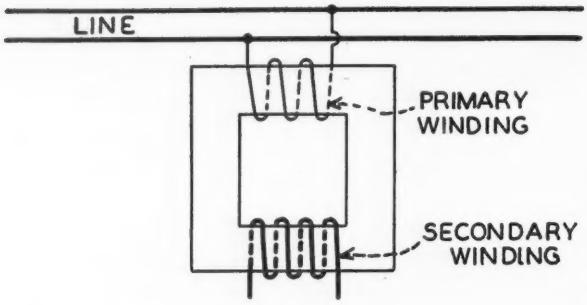


Fig.3

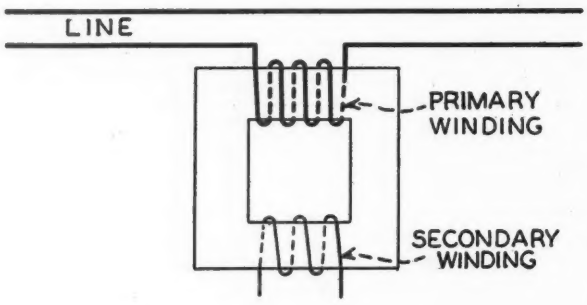


Fig.4

Fig. 3. Potential Transformer Diagram

Fig. 4. Current Transformer Diagram

their catalogs for the standard line voltages. Sometimes, however, the normal line voltage may be different from any of the standard listed voltages. Most potential transformers are suitable for operation either 10 per cent above or 10 per cent below their normal ratings and this range would take care of a good many special cases. If, however, the normal voltage at which the transformer is to operate differs by more than 10 per cent from the normal listed voltages of transformers, it is best to obtain a transformer with a special voltage rating. If operated continuously at a voltage appreciably higher than its nameplate rating, the potential transformer is likely to overheat which will injure the insulation and in time destroy the transformer. When operated at a voltage much lower than its nameplate rating, large errors are likely to be introduced into the result.

Besides their voltage rating, potential transformers are given a power or capacity rating which is usually expressed in volt-amperes. For example, some potential transformers have stamped on their nameplate 50 volt-amperes. This means that the secondary output of this transformer should be limited to about 50 volt-amperes if accurate performance is required. Others have ratings of 100 v-a., 200 v-a., 500 v-a., etc. The selection of the proper transformer by volt-ampere rating depends on the type meters or devices the transformer is to operate. This will be explained later under the discussion of burdens and accuracy classification of transformers.

Current Transformers

If the two electrical circuits of a transformer are designed so that the current taken from the secondary circuit has a definite relation to the current passing through the primary circuit, the transformer is known as a current transformer. In use, such a transformer is connected in series with one of the line conductors (See Fig. 4). With this connection the full current flowing through the line passes through the current transformer primary circuit. Since the current transformer is designed to transform a high current to a low current, the amperes flowing in the secondary would be some definite fraction of the amperes flowing in the primary circuit. For example, if the transformer is designed for use on a circuit having a full load normal current of 100 amp., the primary circuit of the transformer would be designed to carry 100 amp., and the secondary circuit to carry a definite fraction of the 100 amperes. Common practice has made the secondary circuit in most current transformers 5 amp., which in this case would be one-twentieth of the primary current and the transformer would be described as having a ratio 20:1. A drop in the line current below the 100 amp. which is the full load rating of the transformer would produce a proportional drop in the secondary circuit current, as the ratio of the transformer would always remain 20:1 and the secondary current would always be one-twentieth of the primary current. Likewise another transformer could be designed for a primary current of 500 amp. and a secondary current of 5 amp., and since the secondary current is one one-

Fig. 5. Portable Potential Transformer

Fig. 6. Portable Current Transformer

hundredth of the primary current, the transformer would be described as having a ratio 100:1. Another transformer for 1200 amp. primary current would have a ratio 240:1, etc. Most current transformers have a 5 amp. secondary current for a full rated primary current, although the use of other secondary ratings is quite common, especially in current transformers designed for use with relays and control devices.

In selecting the proper current transformer for any installation the circuit voltage and the normal line current must be considered. Every current transformer has a voltage rating as well as a current rating. This means that the current transformer is designed for use on circuits of certain voltages. It is common practice on circuits below 15,000 v. to give the current transformer a maximum voltage rating. For example, a very large percentage of current transformers for low voltage service are rated 5000 v., which means that they can be used on any circuits on which the potential does not exceed 5000 v. Another group of current transformers are rated 7500 v. and a third group 15,000 v. Each group of current transformers therefore includes several of the standard line voltages. Above 15,000 v., however, the current transformers are given a voltage rating equal to the normal line voltage. It is understood that they are satisfactory for use on voltages which exceed this rating by the usual amount of transmission line voltage fluctuations.

The normal current in the line will of course determine the current rating of the transformer that must be selected. Also a knowledge of the probable fluctuations in the line current is essential. Most current transformers will not stand continuous operation above their normal current rating, but will stand momentary fluctuations in the current such as are produced by motor starting currents. Satisfactory operation of current transformers will be obtained from about 5 or 10 per cent up to 100 per cent of their full load rating. It is therefore usually desirable to select a current transformer so that with normal full load current in the line the transformer will be operating at from 60 to 80 per cent of its full current rating.

Use With Meters

The use of instrument transformers as described above now provides for the meters a potential of 115 v. in place of the high line voltage, and a current which will have a maximum value of 5 amp. The meter need then be designed for only 5 amp. and 115 v., instead of the higher line values. Since the current and potential applied to the meter bear a definite ratio to the current and potential of the line, the values read on the meters need only be multiplied by this ratio to determine the value of the line current or voltage. For example, if a current transformer rated 100/5 amp., ratio 20:1, is used with a 5 amp. ammeter, any value read on the ammeter should be multiplied by 20 to give the line current. If the ammeter reads 4 amp., the line current will be four times twenty or 80 amp. Likewise, if a potential transformer rated 575/115 v., ratio 5:1, is used with a voltmeter, the values read on the voltmeter need only be multiplied by five to obtain the line voltage. If the voltmeter reads 112 v., the line potential is five times 112, or 560 v. If a wattmeter is used with both current and potential transformers, the readings of the wattmeter must be multiplied by both the current transformer ratio and the potential transformer ratio to obtain the line power. For example, if a wattmeter is used with a current transformer rated 100/5 amp., ratio 20:1, and a potential transformer rated 575/115 v., ratio 5:1, the reading of the wattmeter must be multiplied by 20 and again by 5 to get the power of the line; i.e., if the wattmeter reads 450 watts, the line power is 450 times 20 times 5 or 45,000 watts.

It is usually not necessary for the operator actually to perform these multiplication operations. On most switchboard installations this multiplication is taken care of by properly marking the instrument scale. For example, if an ammeter is to be used with a 100 amp.-current transformer ratio 20:1, the ammeter would have a 5 amp.-coil. However, instead of marking the scale 5 amp., it would be marked with a value of twenty times five, or 100 amp. The multiplication of the current in the ammeter by the transformer ratio is therefore already taken care of, and the reading of the ammeter scale would give the line current. In the same

Fig. 7. Portable Current Transformer

manner, the scale of voltmeters, wattmeters and other instruments are marked so they indicate the line voltage power, etc., without requiring that the operator perform the multiplication by the transformer ratio.

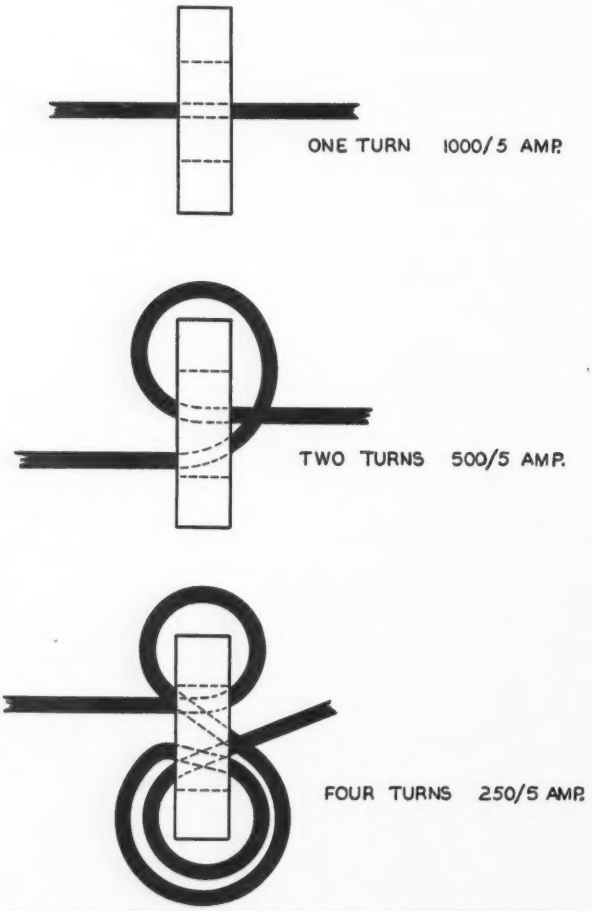


Fig. 8. Ratio of Portable Current Transformer with Cable for Primary

Only in cases where the instrument scale is marked in terms of the actual instrument capacity, such as 5 amperes and 115 v., must the multiplication be performed by the operator.

Portable Transformers

There is no fundamental difference in electrical design between switchboard and portable transformers. The differences are entirely mechanical. As their name indicates, portable transformers are not intended for a permanent installation, but are designed to be carried from place to place as the requirements of various testing work may dictate. Portable transformers are usually used with portable instruments which have the scales marked in secondary values, namely, on the basis of 5 amperes and 115 volts. This therefore necessitates that the instrument readings be multiplied by the transformer ratios as described above. As a rule, portable transformers are made so that several ratings can be obtained from one transformer, thus making them readily adaptable for use under different conditions. Fig. 5 shows a typical portable potential transformer. This transformer is designed for use on either a 230 v. line or a 460 v. line, and, by selecting the proper primary terminals, a ratio of either 2:1 or 4:1 can be obtained.

Portable current transformers of several typical constructions are shown in Figs. 6, 7 and 9. Fig. 6 shows a construction that has either 3 or 6 primary ratings. Such a construction provides very flexible equipment for testing over a wide range of current ratings. The primary winding of this transformer consists of a number of coils, each having two terminals on the top of the transformer. These terminals are in the form of threaded studs provided with thumb nuts. Metal straps are provided to clamp under the thumb nuts to connect the coil terminals together. These straps can be connected several different ways to obtain different ratios. For example, if these straps are arranged to connect all the coils in parallel, the maximum current rating is obtained, and if the straps are arranged to connect all the coils in series, the minimum current rating is obtained. Intermediate current ratings are obtained by connecting the coils in different combinations of series-multiple connections.

Fig. 9. Portable Current Transformer

Another style of portable current transformer is illustrated in Fig. 7. This transformer has no primary winding. Instead an opening or window is provided in the transformer core, and the operator provides the primary winding according to the requirements of the test on which the equipment is to be used. A suitable cable or conductor is passed through the transformer window one or more times (See Fig. 8). This cable or conductor acts as the transformer primary. The transformer has a ratio of 1000/5 amp., i.e., if a conductor is passed once through the transformer window and 1000 amp. passed through the conductor, 5 amp. will flow in the secondary, and the transformer will have a rating of 1000/5 amp., or a ratio of 200:1. Again, if the primary conductor is passed through the window twice, the transformer ratio will be one-half of its former ratio, and the transformer then will become a 500/5

amp. transformer with a ratio of 100:1. Likewise if the primary conductor passes through the window four times, the ratio will be one-fourth of its original ratio, and the transformer then operates as a 250/5 amp. transformer, ratio 50:1. Each time that the conductor is passed through the core window is counted as a turn even though the conductor does not pass around the outside of the core.

Another type of portable current transformer is illustrated in Fig. 9. This type is a combination of the two previously described. A primary winding is provided for low current ratings and connections are made to terminals on the top of the transformer. A hole in the core is provided for a conductor when high current ratings are required. This conductor may be passed through once, twice or more times, in the same manner as was described in the previous paragraph.

Polarity

A word frequently used in connection with instrument transformers is polarity. The significance of this term must be understood by workmen handling transformers, if incorrect connections are to be avoided. The polarity of a transformer may be indicated in several different ways. Sometimes one of the primary terminal bushings and one of the secondary terminal bushings are painted white; in other cases, the letter H1 is stamped on or near one of the primary terminals and the letter X1 is stamped on or near one of the secondary terminals. Other methods of marking may be used, but every transformer will have a permanent polarity marking of some character. The significance of these markings is that at the instant current is flowing toward the transformer in the primary lead with the polarity mark, current is flowing away from the transformer in the secondary lead with the polarity mark. This means that when a connection is made to a secondary terminal having a polarity mark, the effect, considering the direction of flow of the current, is the same as if the primary conductor with the polarity mark were detached from the transformer and connected directly to the secondary conductor. It is important that these markings be carefully observed, especially in polyphase work; otherwise it is quite possible to connect a polyphase meter with the elements bucking each other, and thus cause large errors in the indication of the meter.

Ed. Note: This is the first of two articles on this subject by Mr. Townsend. Another will appear in a subsequent issue.

Air Conditioning Business Facts

Based Upon Reports from various sources, including manufacturers of equipment and public utilities throughout this country, the air conditioning industry is stepping along at a very rapid clip. For the first four months of 1936 according to a report issued by the Bureau of Census, the monthly statistics on the value of orders booked by 98 manufacturers for air conditioning systems and equipment total $11,667,129. The total value of orders booked by these same manufacturers during March amount to $3,477,752 as compared with $2,611,241 for February, an increase of 33.2 per cent.

Now there are approximately 175 manufacturers of air conditioning equipment in business today, of which approximately 18 manufacturers produced unit systems of the self-contained type, central station systems which include evaporators and compressors remotely installed. Of this group the value of orders booked for the first four months' period of this year amounted to $5,517,994 of the $11,667,129 which was booked by the total group of the 98 aforementioned.

It must be pointed out that the 175 manufacturers of air conditioning systems and equipment comprise all manufacturers who produce accessories for complete installations, such as condensing units, evaporators, electrical control, air washers, filters, humidifiers, various types of fans, unit heaters, etc. During 1935 this group of manufacturers had a total record of orders booked in the amount of $48,244,800. This was divided on a percentage basis as follows: Small stores and shops, 21.9; large stores, theatres and public buildings, 19.9; industrial installations, 19.7; complete residential all-year equipment, 17.9; railway cars, 10.7; single room or office units, 9.9.

Manufacturers of air conditioning equipment, principally those manufacturers producing condensing units and evaporators who have followed the practice of carefully engineered installations, and insisting that the ultimate user listen to their engineers in letting them give them what their applications demand—systems made up of the correct equipment properly engineered and assembled to meet the particular requirements, will undoubtedly create an expanding and profitable market for many industrial products such as motors, controls, pumps, insulation, sheet metal, fans and blowers, valves and fittings. In this respect a directory of air conditioning equipment for commercial and industrial purposes lists several hundred such manufacturers' names.

Sun Power

At the World Power Conference in Washington, Sept. 7 to 12, Dr. C. G. Abbot, secretary of the Smithsonian Institution, is to demonstrate a ½-hp. steam engine run by sun heat, the apparatus being efficient enough to meet commercial requirements. Three parabolic metal mirrors concentrate the sun's rays along a narrow line upon a series of pyrex tubes which deliver the fluid, Aroclor, a chlorinated diphenyl, compound made by the Monsanto Chemical Co., to a boiler. Three concentric tubes are used to a set, 1¼ and ⅞-in., with high vacuum between to prevent radiation, and a ½-in. inside tube which carries the liquid. This inside tube is metal plated on the top third of the circumference and the Aroclor has a slight addition of lampblack, so that almost the total focused solar heat is absorbed.

Experiments as well as theory indicate an overall efficiency of 15 per cent from sun heat to delivered power, boiler efficiency being 40 per cent. For the present, applications will probably be for water heating, cooking, air conditioning and small power plants in cloudless regions where fuel is scarce. Heat efficiency compares with coal at $3 a ton but the "sun boiler" is somewhat expensive, and for cloudy regions, storage of energy must be provided, hence the system will not be a competitor of fuel burning plants where fuel is plentiful and inexpensive.

Life Expectancy *of* Lamps

By Ralph R. Brady
Westinghouse Lamp Co.

PEOPLE GET 1700 PER CENT more light for a penny today than 15 yr. ago and the annual lighting bill per family has decreased 40 per cent in the last 20 yr., but the public still fails to realize that light is relatively cheap.

More and better light for money expended is often the outgrowth of exact knowledge of incandescent lamps. There are some 10,000 different kinds of lamps on the market today. Hence, to select just any lamp for reading may easily be the cause of big lighting bills. To get the light they pay for, users should know something about the standard lighting lamps for the home, office, store, and school. Also, each lamp varies somewhat in performance which is a factor that should be understood.

Life Expectancy

An incandescent lamp may be regarded somewhat as a human being is by an insurance company. From all its policy holders they can gather the actuarial facts which enable them to catalog insurance risks and compute life expectancy. Manufacturers do the same thing for incandescent lamps. But the public cannot benefit from this information if they do not use lamps properly.

Incandescent lamps may be designed for any life desired but long life sacrifices efficiency. Conversely, a lamp which produces light at high efficiency sacrifices lamp life. After all, lamps are used merely to produce light at night, so their efficiency or light-producing capacity deserves first consideration though life naturally must be long enough for convenience and economy.

An incandescent lamp merely transforms electricity into light. Its inherent worth is measured by efficiency, or how well it performs that function and by life, or how long it continues to perform that function.

A 100-watt Mazda lamp costs only 20 cents. Yet, during its average life of 750 hr. it consumes 75 kw-hr. of electricity. At five cents per kw-hr. this would cost $3.75, or over 18 times the cost of the lamp. As a general rule, current cost will be from 10 to 15 times greater than lamp cost.

Comparatively speaking then, lamp cost is insignificant. We must realize that every lamp bulb will, in time, require electricity costing several dollars. The point is to be sure that the lamp produces the most light for the wattage it consumes, commensurate with reasonable life. That's where efficiency comes in.

For general service lamps, a life of about 1000 hr. is accepted as proper. The most economic life, as a balance between lamp cost and current cost, is less than 500 hr. but the longer life figure has been used largely from the dictates of convenience. Some lamps for special services may have a longer or shorter life because of unusual conditions. Their life may be governed by such considerations as inaccessibility in the case of sign and street series lamps at one extreme, or the maximum wattage with minimum bulb size of projection lamps at the other extreme.

The rated average life of lamps for several classes of service is given in the following table:

Lighting Purpose	Rated Average Life in Hours
Projection	50
Airport Floodlight	100
Spotlight	200
Headlight	500
Decorative	750
Floodlight	800
General	1000
Sign	1500
Street Railway	1500
Street Series	2000

When life is mentioned, it implies "average" life of a group of lamps because it is impossible to guarantee the life of any individual lamp. Continuous testing in the lamp factories makes it possible to predict the average performance of any particular type of lamp.

The accompanying chart, known as a mortality curve, indicates the rate at which burnouts may be expected if a large number of lamps are installed for service and allowed to burn until all burn out. Naturally, the consumer cannot do this, because he must replace each lamp as it burns out. The number of lamp renewals which may be expected in a given installation over a given period of time, provided there are no adverse operating conditions affecting the average life of the lamps, may be determined by formula, namely:

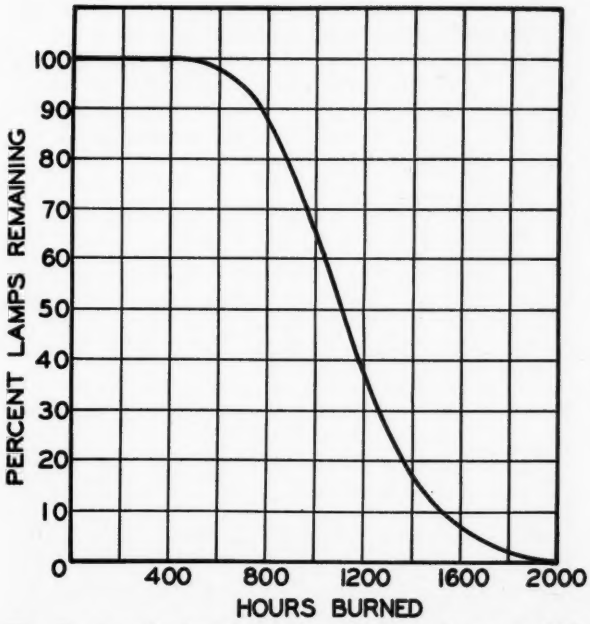
$$\text{Expected number of lamp renewals per year} = \frac{\text{No. of lamps in installation} \times \text{Average hr. actually burned per yr.}}{\text{Rated Life of Lamps in hr.}}$$

Defining Efficiency

The efficiency of incandescent lamps is expressed in terms of lumens per watt. A lumen is the amount of light falling on a surface one square foot in area, every point of which is one foot from a uniform source of one candlepower.

Vacuum lamps, those up to 25 watts, vary in efficiency from about 6 to 10 lumens per watt. Gas-filled lamps, those of 40 watts and up, vary from 10 to 30 lumens per watt. In general, lamp efficiencies are greater in the higher wattages and increase with the wattage. In percentage of total wattage, there is a smaller heat loss in higher wattage lamps. Also, the filaments are thicker and can better withstand higher operating temperatures. For this reason, to obtain a given quantity of light, without reference to distribution, glare, or other illumination principles, a high wattage lamp is more economical than a number of smaller lamps.

For example, suppose we want to obtain approximately 20,000 lumens of light for a period of 1000 hr. The 1000 watt, 115 v., general lighting service lamp has an efficiency of 20.5 lumens per watt. The one lamp will give 1000 × 20.5, or 20,500 lumens. The efficiency of a 200 watt lamp is 17 lumens per watt. If an equivalent wattage is used, five lamps will give 5 × 200 × 17, or 17,000 lumens, falling short of the light requirements. However, six 200 watt lamps will give 6 ×



Mortality curve for incandescent lamps indicates the rate at which burnouts may be expected if a large number of lamps are installed for service and allowed to burn until all burn out

200 × 17, or 20,400 lumens, which is approximately the same as the 20,500 lumens from a single 1000 watt lamp. In the end, the extra 200 watts of electric energy to obtain this light at a 5 cent rate would amount to $10.00 for the 1000 hr. period. Thus, in many industrial and commercial areas, the use of higher wattage lamps, where they are so installed as to conform to good lighting practice, can effect considerable economy in operating costs.

Measuring "Pep" in Lamps

To design a lighting installation that will continue to operate efficiently, it is important to know not only the initial lumen output of the lamps but also how nearly they maintain this value throughout their life.

The total lumen output of lamps, operated on constant voltage circuits, falls off gradually during life for two reasons.

First, as the filament incandesces it sublimates slowly and becomes smaller in diameter. Its resistance, therefore, increases gradually, and allows less current to pass through the wire, thereby producing less light.

Secondly, the sublimated filament material is deposited on the inside of the bulb in the form of "blackening" which interferes with the transmission of light through the glass. Blackening absorbs an appreciable amount of light, depending upon the amount of it deposited within the bulb.

The lumen maintenance of a lamp is the average lumens throughout life expressed as a percentage of its initial lumens. The lumens maintenance of gas-filled lamps is much better than that of vacuum lamps. The convection currents in the gas carry the sublimated tungsten to the upper part of the bulb. When a gas-filled lamp is burned base up, the blackening is deposited in the neck of the bulb where it produces a minimum effect on light emanations. Its lumen maintenance is best when it is burned in this position.

Street series lamps maintain a higher percentage of their initial lumens than do multiple lamps because they are burned at a constant current. Therefore, as the filament grows thinner, more energy is required which in turn produces more light. In smaller sizes of street series lamps this fully compensates for the loss due to bulb blackening.

Closely allied with lumen maintenance is the efficiency which a lamp maintains throughout life. Just as initial efficiency of a lamp is expressed in terms of lumens per watt, so its efficiency maintenance is expressed in terms of the average lumens per watt throughout life in per cent of initial lumens per watt.

Obviously, both lumen and efficiency maintenance should remain as closely as possible to 100 per cent. Much of the research and development work in the Mazda lamp industry has been directed toward this achievement.

A METHOD OF PREPARING yeast from waste sulphite liquor, a nuisance by-product of the sulphite process of cooking paper pulp, was announced recently. This process developed by a Swedish Engineer and in operation for some time in a plant in Europe, has recently been started in a plant in Liverpool, Nova Scotia, where waste liquor from a nearby newsprint mill is used as the raw material. In carrying out this process, the waste liquor is suitably treated by aeration, neutralization and settling, to give a product which, after separation from solid matter present and bringing to the proper temperature is ready for inoculation by the yeast organism. The propagation of the yeast is carried out under conditions generally similar to those obtaining in molasses yeast cultivation.

Reducing That Unaccounted For Loss

In the article under the above title on page 456 of the August issue of Power Plant Engineering, the name of the author was misspelled. The correct name is P. E. Mohn, Asst. Professor Mechanical Engineering at the University of Illinois, Urbana, Ill.

Seals *against* Fluid Pressure

Part V. Materials used and specifications for packings suitable for making seals where sliding contacts are necessary

MECHANICAL packing used in stuffing boxes of all kinds is required, first of all, to prevent leaks around the rods or shafts which must be free to move with respect to the packing. This simply stated fundamental function, however, is surrounded with many difficulties that have led to the use of a variety of materials and many designs of packing and stuffing boxes. The packing must, of course, fit snugly against the rod without providing even a slight passage through which the fluid may escape. This condition immediately presents the problem of friction and how it can be reduced to a minimum for the conditions of operation. Temperature conditions, gland pressure adjustment, stuffing box design, the fluid handled, the working pressure and the function of the rod all have an influence upon the selection of the packing. In answer to the problem, three distinct classes of material are commonly used, namely, fibrous, plastic and metallic. These, usually with some form of lubricant, may be used separately or combined into various combinations of material and design which seem best suited for the service.

Although general in their requirements, federal specifications for packing used for this purpose form the basis from which the character of a packing may be judged and the essential features of these specifications are presented as an aid in selecting suitable materials rather than packing designs and to indicate methods of testing packings for their wearing characteristics.

Braided Asbestos Rod Packing

Two types of braided asbestos rod packing are included in this specification. Type A is plain without wire, while Type B is constructed with wire insertion. The specific application of Type A is for rotary rods and valve stems handling steam up to 300 lb. pressure and 700 deg. F. temperature, or boiler feedwater up to 300 lb. pressure and 200 deg. F. temperature. Type B is suitable for valve stems, expansion joints and fixed joints handling steam up to 500 lb. pressure and 700 deg. F. temperature.

Asbestos yarn rovings, with or without wire insertion according to type, are used in the construction of this packing which in the 1/8 in. and 3/16 in. size may be braid on braid but in all other sizes it is square braided. A core is permitted in all sizes of both types. A warp is not to be included in sizes below 5/8 in. but is allowable in all sizes 5/8 in. and over in both types. The finished packing is approximately square in cross section.

Water of hydration in the asbestos is required to be not less than 12 per cent and the yarn must contain not less than 85 per cent, by weight, of asbestos fiber. A high temperature lubricating compound is used to treat each asbestos yarn or strand and the finished packing is required to be coated with lubricating flake graphite and contain a total not more than 40 per cent, by weight, of lubricant.

In detail, Type A is composed of rovings made of asbestos yarn and a high temperature lubricating compound, while Type B is composed of strands each of which contains two asbestos yarns and not more than four brass or copper wires the size of which is not greater than 0.01 in. in diameter. The weight per linear yard is given in the table.

	Weight per Linear Yard, lb.			
Nominal	Type A		Type B	
Size	Min.	Max.	Min.	Max.
1/8 in.	0.02	0.12	0.04	0.18
1/4 in.	0.10	0.28	0.12	0.30
3/8 in.	0.23	0.44	0.28	0.50
1/2 in.	0.42	0.66	0.50	0.78
5/8 in.	0.66	0.92	0.80	1.12
3/4 in.	0.94	1.26	1.15	1.54
7/8 in.	1.30	1.66	1.60	2.02
1 in.	1.70	2.10	2.10	2.60

To test for water of hydration, take a known weight of approximately 1 gram of the dried material in a platinum crucible and ignite in an electric furnace to a cherry red heat or over a blast lamp to constant weight. The ignited weight of the asbestos, divided by the original weight of the sample and multiplied by 100, gives the per cent of ignited asbestos in the packing. The per cent of ignited asbestos plus the per cent of cotton, subtracted from 100, gives the per cent of water of hydration in the asbestos.

Comparison of the service cost of packing is evaluated by the following formula:

Cost per hour of service = (cost per pound) × (a/b) in which (a/b) is the work value of the packing established by test.

a is the total weight of packing in pounds required for the test when using two different stuffing boxes.
b is the total effective hours of service on test.

High-pressure Asbestos Rod Packing

Packing suitable for piston rods, valve stems, or slip joints, specified as high-pressure asbestos rod packing, may be used under the following conditions: Steam to 300 lb. pressure and 700 deg. F. temperature; water to 300 lb. pressure; brine to 100 lb. pressure; air to 3000 lb. pressure; gas to 75 lb. pressure; or fuel oil to 500 lb. pressure and 250 deg. F.

Only one grade of this packing is specified and this is made of woven asbestos cloth, treated with a protective coating of rubber compound, no wire insertion being permitted. It is made approximately square in cross section and pressed or molded to conform to the exact size required. Rubber friction is not permitted to be used on the outside of the packing where it will come in contact with the rod.

In construction, the asbestos cloth is wrapped tightly upon itself in layers. If desired, the packing may be made plain, with a center rubber core, or with a rectangular rubber spring back, except that where less than 3/8 in. in size it cannot contain a rubber core or spring back. When the packing is made with a rubber spring back, the outside cover stock must consist of not less than two complete layers of cloth. The yarn used in making the cloth contains not less than 90 per cent of asbestos fiber of not less than 12 per cent water of composition. In the weaving of the cloth each strand of the warp and filling consists of two asbestos yarns, and the weave runs not less than 20 strands of warp and 10 of filling per linear inch.

For the central core or spring back, the compound used must contain not less than 60 per cent, by volume, of rubber. Sulphur is limited to 8 per cent by weight of the rubber as compounded, and the cross-sectional area of the rubber core or spring back must not be more than 12 per cent of the nominal sectional area of the packing. Packing with core or spring back must contain not less than 30 per cent nor more than 50 per cent by weight of rubber compound, including the friction compound and the core or spring back prior to lubrication. Packing without core or spring back must contain not less than 20 nor more than 40 per cent by weight of rubber friction compound.

Lubrication in the form of either mineral oil or glycerine must not exceed 20 per cent by weight of the finished product. For external lubrication, the finished packing is dipped in pure flake graphite. The packing is coiled into helices and vulcanized. The inside diameter of the helix must not be less that four times the thickness of the packing. Under steam test with saturated steam at 250 lb. pressure for 8 hr. the packing must not harden nor soften materially and the friction compound must retain most of its elasticity.

Asbestos Valve-Stem Packing

Asbestos packing suitable for small rods and valve stems used in connection with steam up to 300 lb. pressure and 700 deg. F. temperature, hot or cold water or brine to 300 lb. pressure, high and low pressure air to 3000 lb. pressure, or fuel oil to 500 lb. pressure and 250 deg. F. temperature is specified in four types. Type A is braided and lubricated with satisfactory oils; Type B is braided and frictioned with rubber compound; Type C is twisted and lubricated with satisfactory oils and Type D is braided and frictioned with rubber compound.

The chrysotile form of asbestos, with not less than 12 per cent water of composition, is used in making the yarn for this packing. The yarn must contain at least 90 per cent asbestos fiber and 1 lb. of the single-ply yarn must contain 1000 yd. ± 5 per cent.

In construction, Type A is made of a number of lubricated strands of asbestos yarn tightly braided about a central core composed of lubricated strands of asbestos yarn. The lubricant and graphite are limited to 33 per cent by weight of the finished packing. Type B is made of a number of rubber frictioned strands of asbestos yarn tightly braided about a central core composed of rubber frictioned strands of asbestos yarn. The rubber compound must not exceed 10 per cent by weight of the finished packing which must not contain any lubricants other than pure flake graphite in which the finished packing is dipped. Type C and Type D correspond to Types A and B respectively except that the yarns are twisted instead of braided.

Spiral Gland Low-Pressure Packing

Frictioned cotton fabric with top and bottom cover of rubber is specified in spiral gland low-pressure packing as suitable for use on rods subjected to steam up to 100 lb. pressure, hot or cold water or brine up to 300 lb. pressure, air up to 200 lb. pressure or refrigerating gas up to 100 lb. pressure.

The slab stock is built up of layers of frictioned cotton fabric laid on a bias at 45 deg. angle and in alternate directions, each ply overlapping the butted joint of the adjacent ply. Not less than one layer of frictioned fabric is required for each 1/16 in. in thickness, exclusive of the top and bottom covers which are of rubber not more than 3/16 in. in thickness measured to the bottom of the fabric impressions. The weight of the fabric before treatment must be not less than 27.4 oz. per sq. yd. and the rubber must be at least 45 per cent best quality new rubber with not to exceed 8 per cent sulphur in the rubber as compounded.

After being cut from the slab, the packing is coiled into spirals and vulcanized. The inside diameter of the spiral must be not less than four times nor more than six times the thickness of the finished packing, and the cross-section of the packing is square. The spirals are lubricated with mineral oil and dipped in graphite but the amount of lubricant including graphite must not exceed 30 per cent, by weight, of the finished packing.

Subjected to steam test, this packing must show neither ply separation nor material hardening of the rubber when a piece of the finished packing is subjected to 4 hr. exposure to steam at 50 lb. pressure. The friction between plies must be such that a weight of 8 lb. per inch of width will not cause the plies to separate at a greater rate than 1 in. per min. In flexibility, the packing must bend readily, without injury, around rods of sizes as follows: Packing 1/4 to 3/4 in. thick, rod diameter equal to thickness of packing; 7/8 to 1 1/8 in. packing, rod diameter twice packing thickness; greater than 1 1/8 in. packing, rod diameters are three times packing thickness.

Flax Packing

Flax packing conforming to the following specifications is suitable for use on rods and valve stems when handling hot or cold water or brine up to 300 lb. pressure or fuel oil up to 500 lb. pressure. This packing, specified in only one grade, is made from cleaned long flax fiber, braided and squared. It must be free of warp, core, foreign fibers, or substitutes. The packing is thoroughly and evenly impregnated with pure tallow, no other oils or greases are permitted. Special instructions, however, may be given that the packing shall be lubricated with flake graphite that is free from siliceous or other foreign substances.

Specifications require that the length of staple must be such that when a section of packing 20 in. long is carefully unraveled and combed out with a coarse comb, it will give a brush in which 40 per cent of the fiber, by weight, is at least 8 in. long. The quality of the staple is required to be such that when a roving is carefully untwisted and the fibers straightened out, the tensile strength, in kilograms, must be not less than 100 times the weight of the roving expressed in grams per centimeter of length.

Lubrication is obtained by means of tallow, the weight of which must not be less than 35 nor more than 45 per cent of the finished packing. The tallow must be pure and refined, free from rancidity, and must contain not more than the equivalent of 4 per cent of oleic acid. The saponification number must not be less than 192 nor more than 198.

The specified minimum weight of the packing, after the tallow has been extracted with gasoline, is given in the following table:

Size of Packing Inches	Weight per linear yd. min. Pounds	Size of Packing Inches	Weight per linear yd. min. Pounds
⅛	0.012	⅞	0.66
¼	0.054	1	0.84
⅜	0.12	1⅛	1.08
½	0.21	1¼	1.35
⅝	0.33	1½	1.80
¾	0.48	1¾	2.25
		2	2.65

Tucks Packing

Tucks packing is the name of a specific design of packing which is used extensively in the U. S. Navy for rods and inside packed plungers and pistons handling hot or cold, fresh, salt or brine water up to 300 lb. pressure. It may be furnished as Type A which is square, or Type B which is round or square with rubber core.

This packing consists of rubber frictioned cotton fabric layers, with the addition in Type B of a rubber core. The cotton canvas layers are built up on the bias and conform in dimensions, plies and texture to the following table:

Size	¼ to ⅜ inch	½ to ⅞ inch	1 inch and over
Texture of plies	Fine	Medium	Coarse
Number of plies per inch Including friction	38-42	26-30	16-20

In testing for quality, the packing must withstand boiling water under 80 lb. steam pressure for 4 hr., without ply separation or material hardening of the rubber. The packing must not increase in size more than 10 per cent when boiled in water in an open dish for 2 hr. In flexibility, the packing must be capable of easily bending around rods as follows:

Size of Packing	Diameter of Rod
¼ to ¾ in.	Equal to size of packing
⅞ to 1⅛ in.	Equal to twice size of packing
Greater than 1⅛ in.	Equal to three times size of packing

In the test for friction, the rate of separation must not exceed 1 in. per minute under a load of 8 lb. per inch of width.

The diameter of the rubber core in Type B packing must be one-third the diameter of the packing and the tensile strength of the rubber core must not be less than 1000 lb. per sq. in. and the ultimate elongation not less that 250 per cent (2 to 9 in.).

Leather Hydraulic Packing

Packings which go under the name of hydraulic are those intended to work in water, alcohol, oil or any other liquid and are used on hydraulic presses, hydraulic valves and oil presses. The following specifications are intended to cover the requirements for leather in the form of butt bends or sides used for hydraulic packing. The three classes specified are: Class A, light; Class B, medium; and Class C, heavy.

Vegetable tanning materials must be used in the preparation of leather for packings, and the leather must be free from holes, cuts, brand marks, deep wrinkles, and soft spongy spots. The leather must be full grain, with flesh side smooth and free from loose flesh. It may be shaved or leveled to an even thickness, and must not crack open on the grain when bent through an angle of 180 deg. over a rod ½ in. in diameter, grain side out.

Minimum allowable tensile strength of the leather is 3000 lb. per sq. in. but the average must not be less than 3500 lb. The stretch must not exceed 20 per cent in 2 in. at a stress of 2500 lb. per sq. in., and water absorption must not exceed 15 per cent.

In chemical constituents (moisture free basis) the leather is required to meet the following analysis:

Water-soluble material	Max. 15 per cent
Grease (petroleum ether extract)	Min. 12 per cent, Max. 18 per cent
Ash	Max. 1 per cent
Acid	Max. 0.75 per cent
Glucose	Max. 2 per cent

In thickness, Class A is 10/64 up to 12/64 in.; Class B, 12/64 up to 14/64; and Class C 14/64 up to 16.64 in.

Flexible Metallic Packing

Flexible metallic packing that conforms to the following specifications is suitable for service on rods and slip joints under the following conditions: Steam to 300 lb. pressure and 500 deg. F. temperature; water to 500 lb. pressure; brine to 100 lb. pressure; air to 3600 lb. pressure; gas to 500 lb. pressure; and fuel oil to 500 lb. pressure and 250 deg. F. temperature. Although suitable for reciprocating rods with steam, semi-metallic packing is considered more desirable.

This packing is made of soft and pliable metal in

the form of foil, ribbon or strands wrapped, crimped, twisted or braided into a continuous strip with or without a central core, or a light fabric jacket. The entire wearing surface is of metal, which must be of such quality that it will not melt or disintegrate at a temperature below 550 deg. F. When a core is used its location must be concentric and the material used either asbestos rope or rubber strip. The size of the core must be such that there will be at least ⅛ in. of metal completely surrounding it in sizes ⅜ in. and larger; for smaller sizes, at least 1/16 in. of metal must completely surround the core.

Lubricating material and graphite must constitute not less than 5 nor more than 10 per cent, by weight, of the finished packing, based on metal weighing 0.4 lb. per cu. in. For metal of different specific gravity, the lubrication content percentage, by weight, must vary by inverse proportion. It is required that the packing shall be sufficiently flexible to permit of being readily formed into coils to fit a rod, the diameter of which is four times the thickness of the packing.

Metallic and Nonmetallic Plastic Packing

Specifications given for metallic and nonmetallic plastic packings divide them into Grade A and Grade B; Class I, metallic, Class II nonmetallic; Type A bulk form, Type B coil form, cotton covered, Type C coil form, metal foil covered, Type D coil form, braided wire jacket. This packing is suitable for rods and valve stems under the following conditions: Steam to 300 lb. pressure and 500 deg. F. temperature—Grade A, Classes I and II, Types A and B; steam to 300 lb. pressure and temperatures over 500 deg. F.—Grade B, Class I, Types A and B, water and oil to 500 lb. pressure and 500 deg. F. temperature—Grade A, Classes I and II, Types A, B and C; brine to 100 lb. pressure—Grade A, Classes I and II, Types A, B and C; air to 200 lb pressure—Grade A, Classes I and II, Types A, B and C; gas to 150 pressure—Grade A, Classes I and II, Types A, B and C. For expansion and slip joints working with steam to 300 lb. pressure and 700 deg. F. temperature, the suitable packing is Grade A, Class I, Types B and D.

In construction, the different components of Type A and of the core of Types B, C and D must be thoroughly mixed and so held together by the binder as to prevent separation of the various parts. The asbestos fiber used must contain not less than 12 per cent, by weight, water of hydration. The graphite must contain not less than 90 per cent, by weight, of graphitic carbon. The binder must be a material capable of withstanding the temperature conditions for which the packing is required. It is required that the packing shall be sufficiently flexible to be readily formed into coils to fit a rod the diameter of which is four times the thickness of the packing.

The composition of Class I, Type A and of the core of Types B, C and D must be in the following proportion:

Metal particles, minimum	40 per cent
Asbestos fiber, maximum	20 per cent
Graphite, maximum	30 per cent
Binder, maximum	20 per cent

This composition is based on metal weighing 0.4 lb. per cu. in. When metal of different weight is used, the percentages, by weight, must vary accordingly. For Class II, Type A and the core of Types B and C, the composition by weight must conform to the following:

Asbestos fiber, minimum	45 per cent
Graphite, maximum	50 per cent
Binder, maximum	20 per cent

Semimetallic Packing

Packing designated as semimetallic is specified in only one grade, and made of woven asbestos cloth which has been treated with a coating of rubber compound and a suitable metallic member. It has been designed as suitable for reciprocating rod service with steam to 300 lb. pressure and 500 deg. F. temperature, water to 300 lb. pressure, air to 3000 lb. pressure, gas to 75 lb. pressure, or fuel oil to 500 lb. pressure and 250 deg. F. temperature.

This packing is composed of a continuous frictioned asbestos cloth member, to which a metallic member is securely fastened. The metallic member is so placed as to present a continuous metal bearing surface. The asbestos cloth must have not less than 18 strands per inch in the warp and 9 strands in the filler, the yarn containing not less than 85 per cent by weight of asbestos fiber of not less than 12 per cent water of composition. The rubber friction compound must be free from all substances which might injuriously affect the quality.

Metal used in this packing must be of a composition that will not score the rod, melt, or disintegrate at a temperature below 550 deg. F. or chip or flake off by reason of the abrasive action of the rod. The metal must form at least 60 per cent by weight of the packing, based on metal weighing 0.4 lb. per cu. in., the percentages changing according to the specific gravity of the metal. No lubricant is contained in the packing except that it must be dipped in pure flake graphite. This packing must be sufficiently flexible to permit of being readily formed into coils to fit a rod, the diameter of which is four times the thickness of the packing.

(To be continued.)

U. S. Oil Reserves—Correction Note

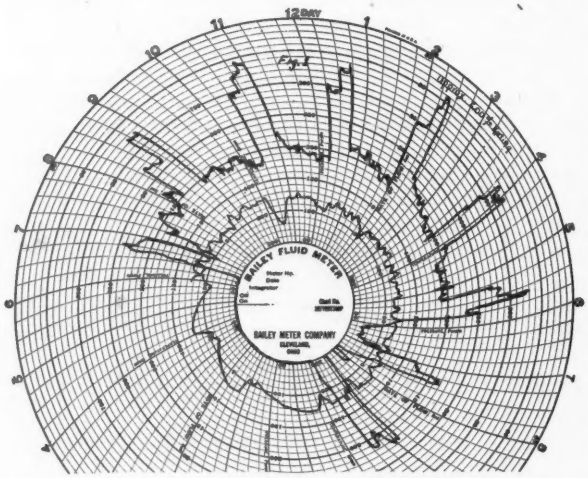
Attention has been called to two misprints in the table at the bottom of page 463 in the August issue. In the 1913 column 67.1 should be 87.1 and in the 1923 column 62.4 should be 63.4. The corrected table which shows the per cent of total heating value contributed by the several mineral fuels of the United States is as follows:

	1913	1923	1934
Anthracite	14.4	10.9	8.4
Bituminous coal	72.7	63.4	50.8
Total coal	87.1	74.3	59.2
Oil	9.3	21.1	30.5
Natural gas	3.6	4.6	10.3
Total mineral fuels	100.0	100.0	100.0
Water power	3.4	4.9	10.2

Instruments a Factor in Discovering Heat Wastes and Bettering Load Conditions. By Francis A. Westbrook

Distillery Peak Loads *Reduced* 25 Per Cent

EXPERIENCE has frequently shown in the past that a boiler plant which is believed to be inadequate may, after an analysis of the load placed upon it, be made to function with an adequate margin. This has been the experience of Ellis W. Coates, Superintendent of the Readville Distilleries, Inc., Readville, Mass. As is well known, a distillery has a very irregular demand for steam with high peaks during the cooking and distilling operations when the boilers are liable to be taxed to the limit, which was the condition at the Readville Distillery until measures were taken to correct it.



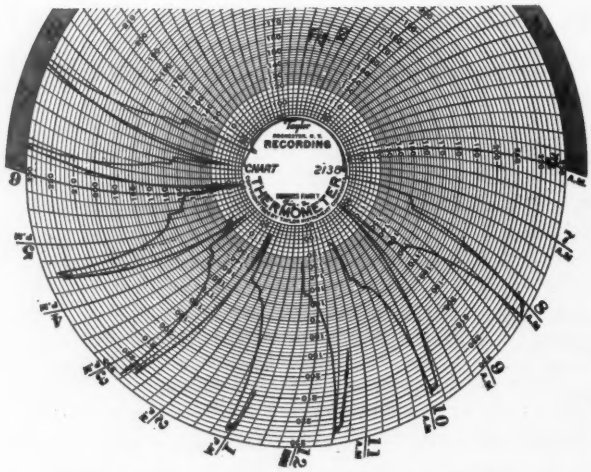


Fig. 1. Former load conditions of boilers
Fig. 2. Temperature conditions formerly in cooker

The boiler plant consists of two 266-hp. h.r.t. boilers which are operated at 130 lb. pressure and which are oil fired. Each boiler is equipped with two mechanical burners, and at the peaks both burners were operated. In fact it was necessary to force the boilers to such an extent that the flame from the upper burner showed signs of having a bad effect on them, and the question of providing greater steam generating capacity was seriously considered. Before doing this, however, it was decided to install a steam flow meter with the hope that a study of the charts would suggest some other means of meeting the difficulty.

One of these charts is reproduced in Fig. 1. It shows the five peak loads from the combined operation of the cookers and beer still. At such times the boilers were running at about 200 per cent of rating and it will be noted that there was a corresponding drop in the pressure of the steam. The temperature chart of the cooker operating under old conditions is shown in Fig. 2 and it will be seen that the maximum temperature here was held for only about 15 min., or less time, usually. When the steam was turned into the cold mash of the cookers practically all of it was drawn away from the stills on account of the condensation which took place. It is to be noted that these peaks as shown on chart, Fig. 1, lasted half an hour, which is a measure of the time required to reach the maximum temperature of the chart Fig. 2.

In addition to the five big peaks there are three small ones when only the cookers are operated. These are not so serious from the standpoint of boiler capacity but still wasteful of steam under the old conditions.

The first step taken to correct the peak demand was to go through the plant and try to schedule as many as possible of the various operations involving the use of steam for pumps, steaming out fermenters, heating yeast mashes and so forth so that they would not come at the same time. This helped somewhat, as the boiler meter charts showed, but it was not enough.

The next step was to return the hot water from the still condensers to the cookers and use it for mashing purposes. Thus when the steam is turned into the cooker it now goes into a hot mash and as a result there is much less condensation and much less steam is required for cooking. It actually cuts in half the time during which the steam valve has to be open, that is from about half an hour to about 14 min. This

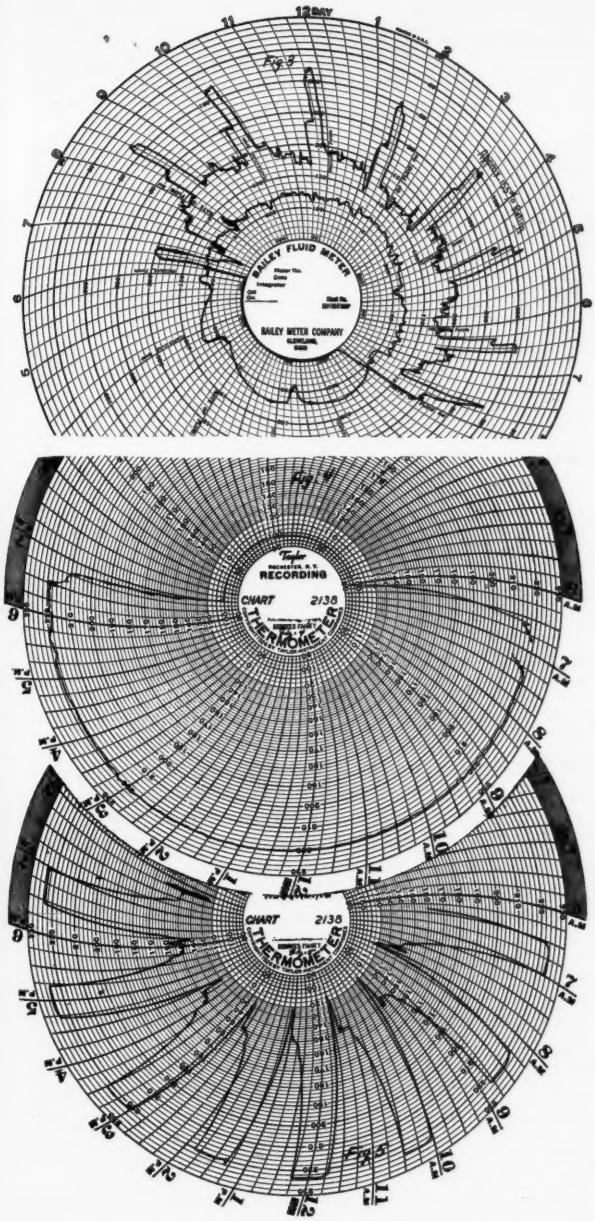


Fig. 3. Boiler load conditions after revisions made in plant
Fig. 4. Record of temperature in beer stills
Fig. 5. Record of temperature in cooker after conditions were corrected

shows plainly in the chart, Fig. 3. It also shows that the steam flow is only about 150 per cent of boiler rating instead of 200 per cent and that there is only a slight drop in the steam pressure.

As the steam consumption in the cooker was reduced it made it possible to keep steam on the beer stills more evenly and for a longer period at maximum temperature, as indicated by Fig. 4, which is desirable from the distillers' standpoint. By way of contrast, Fig. 5 shows a temperature chart on the cooker after conditions were corrected. This is the same operation as shown in Fig. 2, prior to changes herein described.

All of this was accomplished by using hot water for the cooker which was otherwise wasted and by doing only a small piping job, the cost of which was negligible. It is now not necessary to operate more than one oil burner per boiler and there is a reduction of 20 per cent in fuel. In other words by making an analysis of the steam demand with the help of the steam flow meter it was possible to take these simple measures which have made it unnecessary to enlarge the boiler plant.

While this experience has to do specifically with a distillery, it is an excellent example of what it may mean to be able to study the realities of the demand for steam with the help of recording instruments, for without the knowledge which they make available it is often impracticable to take corrective measures. In this case the expense of new boiler equipment has been saved and the operations have been improved, and the same might have been done in any process industry with variations depending on the character of the work.

A.S.M.E. Niagara Falls Meeting

ON SEPTEMBER 16 to 19 the American Society of Mechanical Engineers will hold a meeting in Niagara Falls, N. Y., which will be devoted to the discussion of subjects relating to power, fuels and industrial processes. The program includes a special inspection trip to the General Electric Co. plant at Schenectady and will afford an opportunity to meet many of the foreign engineers who are in this country to attend the World Power Conference which will be held in Washington the preceding week, September 7 to 12.

Wednesday, September 16, will be spent in the General Electric plant with the morning given over to plant inspection, luncheon in the plant and in the afternoon there will be given an unusual series of short talks on technical developments. The inspection of the factory will include visits to the House of Magic and special exhibits.

At Niagara Falls the Program will commence on Thursday at the headquarters at the Hotel Niagara. The Power and Hydraulic sessions have been arranged so as to coördinate with the post-convention tours of the World Power Conference. Five tours will be routed to Niagara Falls for the meeting. Several European engineers will be speakers in the technical sessions.

The technical program opens on Thursday morning at the Hotel Niagara with one session on Power and one on Transportation. Thursday afternoon there are three sessions covering Power, Materials Handling in Process Industries and Engine Design. Thursday morning there will be from 9:00 a.m. to 10:00 a.m. a special talk on Interconnection of Power in the Niagara District to be followed by an inspection trip to the Huntley Station plant which can be inspected either Friday morning or afternoon. At 10:00 a.m. there will be three regular technical sessions, one on Fuels, Hydraulic Research and a third on Wood Industries. Friday afternoon there will be two technical sessions, one on Hydraulics and one on the Process Industries. Friday evening there will be a session of the Wood Industries Division.

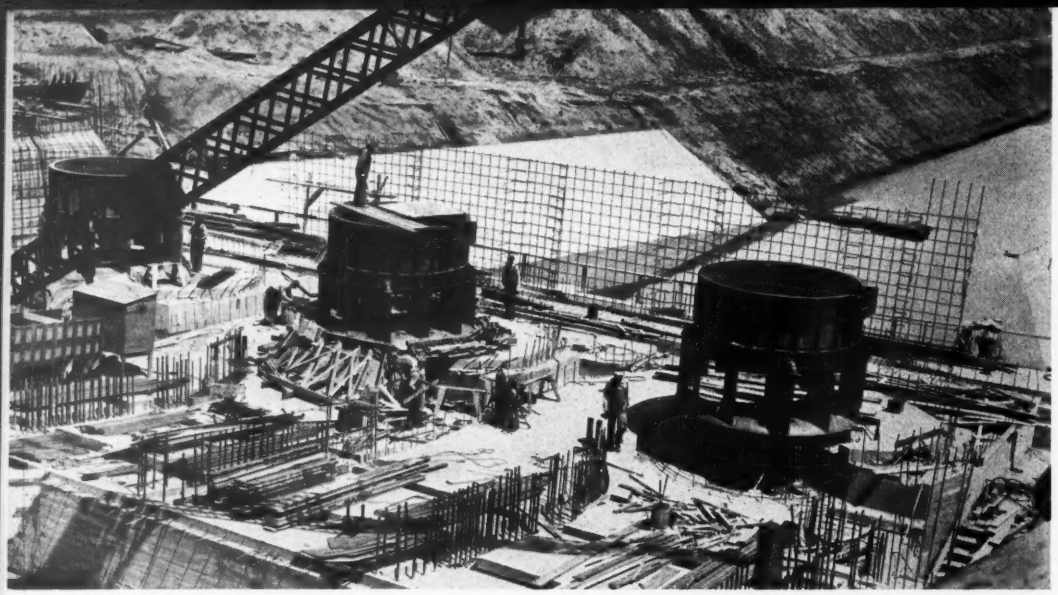


Fig. 1. View looking downstream at the Monroe Power House under construction

Power *from the* Loup River

Continuous Flowing Prairie Stream Fitted with 63,600-hp. Harness

IN THAT plains country on the west side of the Missouri River extending to the foothills of the Rockies, the elements have played an interesting game with the surface of the earth above the deeply buried rock strata. At apparently recurring intervals drouths have destroyed vegetation; winds in the form of tornadoes and near hurricanes have tossed the top soils about leaving them in disordered mounds or ridges; rains and occasional cloud bursts have formed in this top surface furrows, pockets, draws, canyons, broad valleys where the course of flowing streams has cut its way through the top soil back and forth from one bluff to the other. This process, ages old, has made in this territory water sheds almost without a waterfall, due to the absence of rock strata, but with a uniform grade hundreds of miles in length that carry the surplus surface water to the Father of Waters.

One such stream is the Loup River which has its source in three branches that originate with springs and surface waters in the northcentral section of Nebraska. The flow of this stream is phenomenally constant without a time on record when no water was flowing, which is a frequent occurence with other rivers in this plains country. The minimum flow recorded by the U. S. Geological Survey was 800 cu. ft. per sec. in 1892; this year, 1936, with other streams dry the minimum flow of the Loup has been 920 cu. ft. per sec. For mile after mile above the place where the Loup discharges into the Platte River near Columbus, the grade of the river bed is between 7 and 8 ft. to the mile resulting in a fast flowing stream of no practical value for navigation but it has long been recognized as a potenial source of power.

For the past 40 yr. the problem of harnessing the Loup has been worked over by engineers and promoters and numerous proposals have been submitted, all to no avail until in the fall of 1932 a group of citizens of the community undertook the problem of securing financial assistance from the Federal Government in a public enterprise to be owned by the Loup River Public Power District. Thus it was that, with a 70 per cent loan and a 30 per cent grant from the government, this $7,300,000 enterprise, publicly owned and operated in the interests of the district, got under way and operation of the two plants now in the course of construction will start in the spring of 1937.

The hydroelectric project as designed for the generation of power only, without any provision for irrigation. The diversion dam with desilting works is being constructed about 4 mi. southwest of Genoa. The river water will be diverted to the canal and conducted through the valley to the north at a grade that will bring it to the top of the bluffs at a point north of Monroe where the first power house is being constructed. The tail waters from this plant again skirt the bluffs until at a point north of Columbus they enter a storage reservoir on the top of the bluffs from which they discharge through a canal and intake to the Columbus Power House from which the tailrace leads the water back to the Platte River.

In the Monroe Power House are three hydraulic turbines each rated at 3200 hp. or a total of 9600 hp. These drive generating units of 2600 kw. rating each, supplying current at 6900 *v*. The operating head here is 32 ft.

At the Columbus Power House, three steel pen-

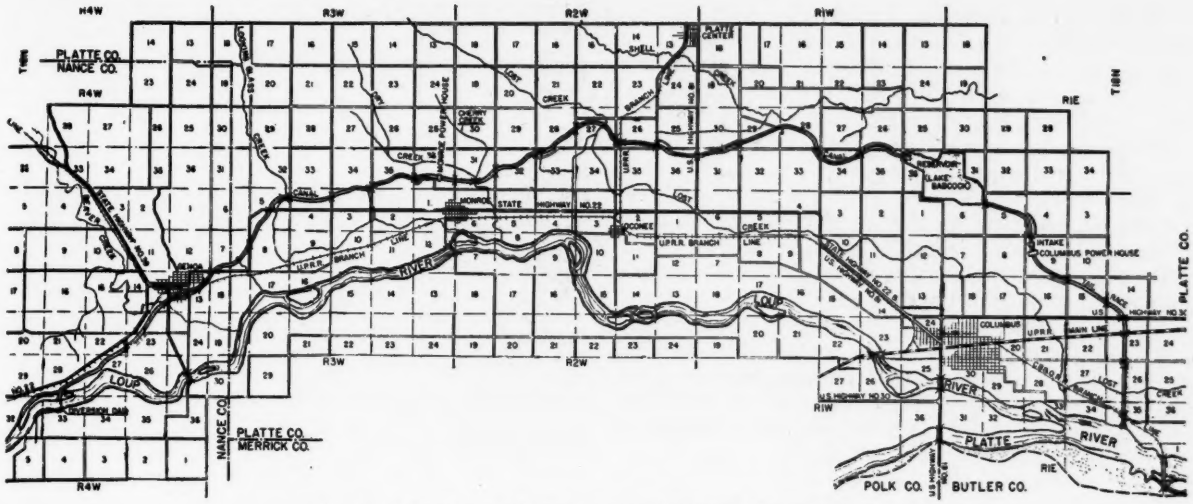


Fig. 2. General map of Loup River Public Power District Project

stocks each 20 ft. in diameter and 300 ft. long, conduct the water from the canal to the three turbines each rated at 18,000 hp. and working under a head of 112 ft. The capacity of each of the generators operated by these turbines is 13,300 kw. or a total of 39,900 kw. for the plant, the generator voltage being 13,800.

These two plants will have an estimated firm power output of 140,000,000 kw-hr. per year, with a dump power output estimated at 100,000,000 kw-hr. Marketing this amount of power is one of the big problems facing the officials of the District and it is expected that electrical hookup will be made with Lincoln, Omaha and Sioux City as well as smaller cities within a 100-mi. radius of Columbus.

From the head works to the tailrace weir, the canal is approximately 35 mi. in length, and at no place in this entire length was rock encountered, enabling almost exclusive use of drag lines and power shovels. The canal is an open ditch, about 90 ft. wide at the water surface, varying from 28 to 60 ft. at the bottom and carrying a stream of water ranging from 12 to 20 ft. deep, flowing at the rate of 1.8 mi. per hr., the grade being 4 in. per mile. It is planned normally, to divert 3000 sec.ft. of water from the river, while the storage and regulating reservoir are designed for a range between 1750 sec.ft. as a minimum to 3500 sec.ft. as a maximum. This plan calls for use of all the water flowing in the river during the lowest stages but only about 10 per cent of that flowing at the peak stages.

Provision is made for only one reservoir which is located just above the Columbus Power House, the Monroe plant being designed to operate as a run of stream plant with the water level controlled at the head gates and the units automatically cutting in and out as the load demands. The surplus water not required for power is bypassed. As the system becomes loaded, this plant will be operated continuously at full load, the swing in load on the system will be taken by the units in the Columbus plant, which is the function for which the reservoir has been provided. The reservoir covers approximately 1000 acres of land and has a storage capacity of 11,000 acre feet. To prevent erosion due to wave action by the prevailing southwest winds, the face of the dike along the northeast shore of the reservoir is protected by a wall of concrete.

Along the course of the canal the water is carried under three creeks and two railroads by means of concrete siphons. Surface drainage intercepted by the canal is carried underneath the canal by means of five drainage culverts and further cared for by means of approximately 35 smaller structures consisting of

Fig. 3. Early stage in the construction of the Columbus Power House

canal inlets and culverts. Twenty-two steel bridges provide crossings over the canal for country roads, one steel bridge carries a gas pipeline over the canal, five concrete bridges span the canal for state highways, three steel bridges are required for railways and 25 timber bridges provide farm crossings over the canal and drainage ditches.

At the entrance to the reservoir, a zigzag concrete weir maintains constant level of water in the tailrace of the Monroe plant, while a straight concrete weir at the Platte River where the canal ends maintains the level in the tailrace of the Columbus plant.

Harza Engineering Co. of Chicago is directing the engineering work on this project which will be completed the latter part of 1937 but the Monroe plant will be ready for service this fall. The list of contractors for equipment and construction is given in the tabulation.

Contracts Awarded by the Loup River Public Power District

Name	Description	Amount of Original Cont.
Zyback & Sokol	Borings	$ 6,292.00
Haas, Doughty & Jones	Canal Excav. & Earthwork	152,842.50
W. L. Roth	Carpentry	674.60
Behrens & Krumland	Electrical	164.44
Dussell & Son	Heating	1,875.00
W. S. Hardwick Const. Co.	Canal Excav. & Earthwork	168,840.00
Martin-Day Co.	Canal Excav. & Tailrace	260,920.00
Condon & Kiewit Co.	Reservoir & Canal Earthwork	462,509.50
Abel & Dobson	Siphons	187,070.00
Condon & Kiewit	Reservoir Control Weir	17,240.00
Baldwin-Southwark Corp.	Columbus Turbines	243,800.00
The James Leffel Co.	Monroe Turbines	111,750.00
Allis-Chalmers Co.	Columbus Generators	411,000.00
Westinghouse Elec. & Mfg. Co.	Monroe Generators	139,250.85
Carstenson Sand Co.	Culverts, Siphon & Weir	129,603.00
Christie & Mills	Drainage Ditch Excavation	23,988.00
Neb. Bridge Supply & Lbr. Co.	Farm Bridge Timber	13,595.84
Central Bridge & Const. Co.	Farm Bridge Erection	6,794.96
A. Johnston, Jr. Co.	Fencing Erection	4,792.80
Neb. Bridge Supply & Lbr. Co.	Fencing Material	14,920.80
Worden-Allen Co.	Steel for Bridges	78,206.50
Abel & Dobson	Steel Bridges	47,943.00
Condon & Kiewit Co.	Erection of Steel Bridges	132,816.00
W. J. Assenmacher	Monroe Power House	309,611.00
Condon & Kiewit Co.	Columbus Power House	613,177.00
G. G. Herrick	Erection of Turbines & Generators	44,925.00
W. A. Biba Engineering Co.	Culverts & Inlets	23,259.90
Roberts Construction Co.	Bridges & Siphons	177,489.94
Condon & Kiewit Co.	Bridge	37,512.00
G. G. Herrick	U. P. Bridge	45,290.00
Westinghouse Elec. & Mfg. Co.	Switchgears & Switchboards	63,436.00
Condon & Kiewit Co.	Burlington Bridge	18,395.00
Harnishfeger Co.	Cranes	19,879.20
Lakeside Bridge & Steel Co.	Gates, Hoists & Tower	33,521.00
Omaha Steel Works	Transfer Trucks	784.00
Moloney Electric Co.	Transformers	121,500.00
Pennsylvania Transformer Co.	Transformers	64,092.00
Wagner Electric Corp.	Transformers	2,705.00
General Electric Co.	Oil Circuit Breakers	130,072.00
Westinghouse Elec. & Mfg. Co.	Lightning Arresters, Transformers & Bus Supports	39,627.64
Railway & Industrial Eng. Co.	Switches, Fuses	78,430.10
Weaver-Lunger Co.	Bank Protection	$ 3,755.00
Roberts Construction Co.	Siphon Under Tailrace	12,660.20
Morrison-Knudsen	Settling Basin, Inlet Canal, Dikes Near Intake	286,194.60
Christie & Mills	Dike of Skimming Weir	10,235.00
Roberts Construction Co.	Skimming Weir and Canal Transition	62,507.00
Morrison-Knudsen	Intake	232,934.00
Pittsburgh-Des Moines Stl. Co.	Penstocks	115,555.00
Zybach & Sokol	Gravel Backfill for Penstocks	19,120.00
Union Pacific	Columbus Spur Track	13,730.00
Union Pacific	Monroe Spur Track	6,937.00
Northern Natural Gas Co.	Pipe Relocation	1,548.76
Nebr. Cont'l Telephone Co.	Line Relocation	8,424.00
N. W. Bell Telephone Co.	Line Relocation	2,500.00
N. W. Public Service Co.	Transmission Line Relocation	5,000.00
Iowa-Nebraska Power Co.	Transmission Line Relocation	600.00
Postal Telegraph Co.	Line Relocation	54.23
		$5,249,900.01

Springfield's New Lakeside Station

PRINCIPAL EQUIPMENT in Lakeside Station, the new municipal pumping station and power plant at Springfield, Ill., was listed on page 392 of the July, 1936, issue of Power Plant Engineering. We regret that through an accident the soot blowers were omitted from this list and subscribers should add the following data to the middle of the first column of that page: Each of the two boilers is equipped with a 2 in. system of Bayer Balanced Valve-in-Head soot blowers with nine units per boiler. On page 388 of the same article, in the first paragraph under the heading Boilers and Furnaces, the ash fusion temperature of 200 deg. F. should be changed to 2000 deg. F.

CARSON, PIRIE, SCOTT & Co., department store in Chicago, has completed a new air conditioning system for the basement and first floor using the steam jet refrigeration method. The steam consumption for cooling is estimated to be 14,000 lb. per hr. The boiler plant has been remodeled to provide the supply of steam needed for the refrigeration work as well as for heating the store in cold weather. Three new high-pressure boilers, two with automatic coal stokers and one fired by gas, have been installed under the contract.

It is the beginning of an air conditioning program which will probably be extended to all of the floors of the building within the next few years. The cooling load required for the present installation is equivalent to 540 t. of refrigeration.

DURING THE PAST several months, many manufacturers have been running tests on their complete lines of mechanical condensing units, the tests being made in accordance with the requirements of the A.S.R.E. "Standard Method of Rating and Testing Mechanical Condensing Units." Ratings resulting from these tests are being certified by manufacturers to the Secretary of the Refrigerating Machinery Association or to the Secretary of the Refrigeration Division of N.E.M.A. Following the acceptance of a manufacturer's certified ratings by the Association office, the manufacturer is in a position to state, in price books, advertising copy and elsewhere, that the equipment he offers for sale has been tested and rated in accordance with A.S.R.E. Standards and that his test and rating certifications are on file with the Association.

A. S. T. M. Annual Meeting

WITH A RECORD BREAKING ATTENDANCE, a great many actions on proposed new standards and adoption of existing tentative specifications as standard, a number of interesting sessions and intense activity on the part of Society committees, the 1936 (Thirty-ninth) A.S.T.M. Annual Meeting held in Atlantic City, June 29-July 3 was an outstanding one. The registered attenance was 1131. This compares with the previous high in Atlantic City in 1930 of 1092 and exceeds that of any other meeting save the one held in Chicago in 1931 where the large registration of 1451 included an unusually large number of visitors, many drawn by the joint A.S.T.M.-A.S.M.E. Symposium on Effect of Temperature and the first A.S.T.M. Exhibit.*

During the week, there were about 200 meetings of the Society committees during which a number of committees finished work on proposed specifications which will be referred to the entire committee membership and submitted to the Society during the summer. The committees reviewed existing research projects and a number of new investigations will shortly be under way.

Four interesting technical papers and the reports of two committees featured the Fifth Session of the A.S.T.M. meeting devoted to water—the session having been arranged under the joint auspices of A.S.T.M. Committee D-19 on Water for Industrial Uses and the Joint Research Committee on Boiler Feed Water Studies. Committee D-19 reported progress stating that it expects to issue for information later in the year proposed standard methods for the determination of sulfate, hydroxide, total carbon dioxide and total orthophosphate ions—these being based on research work completed by the Boiler Feed Waters Committee. Active work is under way to establish standard methods of analysis of the chloride, calcium and magnesium ions and other work is progressing.

Two of the technical papers were prepared in connection with investigations conducted under a coöperative agreement between the Joint Research Committee and the U. S. Bureau of Mines; Messrs. Schroeder, Berk and Partridge prepared the papers. In the one entitled "The Use of Solubility Data to Control the Deposition of Sodium Sulfate or its Complex Salts in Boiler Waters," it is pointed out that the constituents of a boiler water are believed to exert an important effect upon the cracking of boiler steel—for example sodium silicate and sodium hydroxide tend to produce embrittlement and sodium sulfate tends to inhibit this effect.

Extremely interesting curves are included in the paper expressing conditions under which sodium sulfate will be deposited during the evaporation of boiler water at given initial composition. These curves were based on the results of an extended investigation of the solubility of sodium sulfate from approximately 300 to 660 F. in water and in various complex solutions representative of concentrated boiler waters. If further investigation shows that sodium sulfate either in solution or as solid is necessary to prevent embrittlement, these curves will define the conditions which can or should be maintained.

The other paper by the same authors on "Effect of Solution Composition on the Failure of Boiler Steel under Static Stress at 250 C." details an investigation primarily directed to secure information concerning the chemical factors involved in the production and prevention of embrittlement in boiler steel. The tentative conclusions will be subject to modification with further work.

It is indicated that pure sodium hydroxide has little effect on the load which a steel specimen will carry, but if the specimen has a line of stress concentration, such as a groove, sodium hydroxide definitely decreases the load-carrying ability. Similarities are shown between hydrogen embrittlement and embrittlement by chemically pure sodium hydroxide solutions. It is shown that sodium sulfite is reduced by iron and hydrogen at 250 C. and that this reduction may explain its influence on the embrittlement reaction as well as offer a new view of its effect in the prevention of corrosion.

An investigation on "The Rate of Reaction of Sodium Sulfite with Oxygen Dissolved in Water" reported by Messrs. Hitchens and Towne, Monsanto Chemical Co., St. Louis, Mo., shows that the reaction rate is a function first of the type of water, second of the temperature and third of the excess of the reagent employed. This paper will be abstracted more in detail in an early issue of Power Plant Engineering.

Among the conclusions reached in the paper on "Determination of Dissolved Oxygen in Boiler Feed Water" by Prof. A. H. White and Messrs. Leland and Button of the University of Michigan—the paper being a progress report of work under the auspices of the Joint Boiler Feed Water Committee, is that the direct Winkler method for determining dissolved oxygen may have an accuracy of 0.001 ml. of oxygen in the volume titrated, if there are no interfering substances and the end point is determined electrometrically. Non-volatile interfering substances may be removed by boiling off the dissolved oxygen and collecting it again in distilled water where it is determined by the Winkler method. The oxygen from a 1-liter sample may thus be concentrated to one-tenth of that volume and titrated in a solution freed from all but volatile impurities. Corrections for oxygen introduced with the reagents and for oxidation during exposure are small and capable of accurate determination and the method is indicated as being theoretically sound and free from systematic errors.

Committee D-5 on Coal and Coke announced that it is planning to prepare a method of test for dustiness of coal and coke, since it is desirable to have a standard test method to determine the efficiency of treat-

*See p. 437 July, 1936, issue of Power Plant Engineering for a list of officers.

ing coal and coke with chemical and oil compounds to allay dust and give a clean fuel.

The committee, at a meeting, also agreed to recommend to the Society an important revision of the present Standard Method of Sampling Coal. This revision gives a detailed procedure for the rapid reduction of gross samples of coal to a convenient quantity for transmittal to the laboratory. This is accomplished by mechanical methods of crushing and by riffle samplers. It is believed that this mechanical method of reducing coal samples will be widely used by coal producers and consumers who have occasion to do much coal sampling, as the method is much more rapid and is less expensive than the hand method described in the present standard method. The mechanical method supplements but does not replace the present hand method which is suitable for use by those who only occasionally have to sample coal.

The report of Committee D-3 on Gaseous Fuels, which was organized during the year, outlined in detail the objectives and scope of its various committees. From the beginning it has been the committee's recommendation and understanding that its activities are to be limited to commercially available fuel gases combustible in air. This scope not only covers all of the various types of generally classified city gases but practically all of the so-called bottled gases as well. Although these activities are to be limited to laboratory procedures, there is no doubt that they will affect, indirectly at least, commercial practices.

O. S. Duffendack and K. B. Thomson, University of Michigan, in their paper on "Developments in the Quantitative Analysis of Solutions by Spectroscopic Means" describe two spectroscopic sources for the quantitative analysis of solutions. One consists of a pair of jets from which the solution is made to flow at a uniform rate from reservoirs moved by means of a synchronous motor. A highly inductive spark between the jets is photographed by means of a suitable spectrograph and the analyses are based upon the relative intensities of selected spectral lines of the test elements and of internal standards. The second source consists of a high-voltage alternating current arc between very pure carbon electrodes upon which a drop of the solution under analysis has been evaporated. This source, which is not capable of quite so high a degree of accuracy as the former, has the advantage in that only a drop of solution is required for analysis. The authors point out that one marked advantage in quantitative analyses by such means as those described lies in the fact that the determination rests upon direct measurements with instruments and at no step in the process is it necessary for the analyst to rely upon his judgment.

Of outstanding interest among those covering topics in the field of iron and steel presented at the Thirty-ninth A.S.T.M. Annual Meeting was the one on "Failure of Suspension Bridge Cable Wire," by W. H. Swanger and G. F. Wohlgemuth, National Bureau of Standards, and the "Influence of Time at 1000 deg. F. on the Characteristics of Carbon Steel," by A. E. White and C. L. Clark, University of Michigan and R. L. Wilson, the Timken Steel & Tube Co.

For several years studies have been under way at the National Bureau of Standards on the failure of the cable wire of the Mount Hope suspension bridge which necessitated dismantling the partly built bridge. The original wire brought to a high strength by quenching and tempering was replaced successfully by cold-drawn wire of about the same size, carbon content and strength.

Numerous specimens of both types of wire were subjected to various ranges of fluctuating tensile load while suspended over circular supports of the same radius of curvature as the bridge anchorages. Fractures were obtained in 72 hr. with a maximum load as low as 5 per cent of the load necessary to break specimens from the broken pieces in static tensile tests following the fluctuating load tests. The real damage was done by the bending stresses. When means were provided to prevent bending of the wire as the tensile loads fluctuated, the endurance approached that obtained in fatigue tests on straight specimens.

The way in which the failed wires were placed on the anchor shoes, the high elastic limit of the material, and the fluctuating loads on the wires while the cables were spun and the bridge structure was being erected combined to produce a range of elastic bending stresses in the wires at the anchor shoes. The uniformly fine-grained steel of the wire, surrounded by the brittle, low strength zinc-iron alloy of the galvanized coating, and with numerous surface imperfections acting as points of stress concentration offered inadequate resistance to the repeated elastic bending stresses. Fatigue fractures originating at the surface of the wires were the result. There was definite evidence that the fibrous structure of the cold-drawn wire tended to turn aside such cracks, whereas the hard fine-grained structure of the heat-treated wire could not act in this way.

The second paper mentioned above describes extended time creep tests at 1000 deg. F. on an annealed electric furnace 0.15 per cent carbon steel. The stresses were so selected that rupture of the specimens occurred after different intervals of time in the series of tests, and fractures were obtained in periods up to 14,000 hr. The investigation revealed that the carbon steel loses considerable ductility after prolonged heating under stress at 1000 deg. F.

Among the conclusions reached are (1) that the type of fracture varies depending on whether the temperature of test is above or below the lowest temperature of recrystallization, (2) spheroidization will occur in plain carbon steel under stress at 1000 deg. F., and (3) remanent strain-hardening is manifested in this steel at 1000 deg. F. only when the time for rupture is short, as in the short-time tension test.

Results, together with those previously reported for a chromium-silicon-molybdenum steel, indicate that the influence of testing time on the high temperature physical properties of steel may not always be the same at a given temperature. The characteristic behavior of the alloy and the plain carbon steel is believed to be due to differences in the lowest temperature of recrystallization. In the case of the latter, 1000 deg. F. is above the lowest temperature of recrystallization and the tendency toward recrystallization predominates. On the other hand, for the chromium-silicon-molybdenum steel 1000 deg. F. is either below or within the recrystallization range so that the rate of strain-hardening exceeds the rate of recrystallization.

Readers' Conference

Ammonia in Laid-up Boiler

IN THE MAY number there is a short article in the experience column suggesting the filling of a boiler with ammonia gas when laying it by to keep down internal corrosion. I do not profess to be very learned in chemistry, but from a practical experience with the operation of refrigeration plants I can surmise a number of possible objections to the use of ammonia for that purpose, as follows:

Ammonia will corrode all brass parts contained in the boiler such as brass bushings where feed line enters, brass valves and seats, fusible plugs, water column lower connections when made of brass, safety valve parts, and parts of steam gages.

Ammonia will often spring leaks in flange packing unless the packing is the special kind made for ammonia. Ammonia is a strong solvent for many substances found in packing.

While ammonia is not supposed to attack pure iron itself it has a strong affinity for hard carbon spots in iron and other forms of dross often found in iron pipe as impurities whereby if you have a bad batch of poor quality pipe instead of the regular wrought iron pipe used especially for ammonia work you may find that the ammonia is apparently attacking the pipe and corroding it through making a lot of pin-hole leaks.

Some of this cheap pipe that can be bought on the market will stay tight when used on steam but when you try to build it into an ammonia condenser you will in the course of a few months be bothered with a lot of pinhole leaks where the ammonia has apparently corroded its way through from the inside of the pipe.

I think ammonia in a boiler will be more likely to produce corrosion than prevent it for the following reason: When the oxide of iron is formed on inner surfaces of boilers the coat of rust itself is a preventive of further rusting as long as it sticks firmly to the surface. This is why they paint iron bridges and structural work with iron oxide paint. If I am not mistaken the action of ammonia is to dissolve the film of iron rust from the surface of the metal and thus leave it bare for the further attack of oxygen. Recently I heard of an investigation being made in a certain plant where the steam was used for heating and the siphon traps at the tail end of radiators were giving out at their soldered joints and the party who was investigating it said he thought ammonia or some other alkali in the steam was doing the damage.

During the war I was building up some large refrigeration condensers and as delivery of special ammonia fittings was impossible, I got some fittings made special from a local foundry. On trying to use them I found the quality of cast iron so porous that ammonia would leak out through the pores in the iron although these same fittings would be apparently tight when used with steam.

I also ran into a curious bunch of trouble in connection with an underground cold storage condenser for an ammonia plant. There was a large iron riveted construction basin made for holding condenser stands, wood 4 by 8's were laid in the basin and condenser stands installed on these with short lag bolts. Salt water was used as a spray over the condenser pipes and whenever a pin hole or flange leak occurred the ammonia would mix with the salt water forming ammonium chloride which made a large sized electric battery out of the basin with power enough to ring door bells although there were not dissimilar metals. The ammonia stands began to have such extensive external corrosion that we had to do away with the iron basin and make it of cement. I have also found that ammonium chloride when thus formed by union of ammonia and salt water will make boilers foam very badly.

In U. S. Navy Safety rules it says:

"Ammonia in its gaseous state is spontaneously inflammable. Ammonium hydroxide is poisonous and may be fatal to the human system.

"Ammonium nitrate is inflammable when heated with certain acids.

"Ammonium nitrite is explosive at 70 deg. by percussion.

"Ammonium hydroxide when mixed with salt water produces ammonium chloride which will make a boiler foam.

"Also chlorine mixed with ammonia (nitrogen chloride) is explosive."

I would not care to experiment with ammonia in my boiler. If, however, I am wrong in above I would like for some one to set me right.

Logansport, Ind. C. C. CUSTER.

Thermocouple Application

THE THERMOCOUPLE described by Professor Gustaf A. Gaffert in the May, 1936, issue of Power Plant Engineering may have been used successfully in the measurement of the temperature of superheated steam in a certain experimental set-up, but I am certain that a thermocouple of such construction would not withstand the high velocities in modern steam mains, where velocities of 15,000 to 16,000 ft. per min. are not uncommon.

The experience of many people indicates that it is necessary to enclose the thermocouple in a socket in order to protect it from failure in the high-velocity steam. The open end of the socket should be thoroughly covered with heat insulation in order to minimize the cooling of the closed end, which surrounds the hot junction of the thermocouple, due to heat flow outward along the socket.

Detroit, Mich. W. A. CARTER.

MR. CARTER'S comments on the whipping effect of

high velocity steam in steam lines is a point well taken. We have recognized this fact in specifying rugged, high-strength steel sockets for all temperature recorders and even thermometer wells. After rereading the article, it is possible that I may have given the inference that the experimental thermocouple used in my tests could be used in such an application as Mr. Carter refers to. That was not the intention.

I fully agree that it is necessary to have a rugged thermocouple support, well insulated, but I am certain that a bead or block at the end of the thermocouple junction will tend to dampen temperature fluctuations. To summarize: Mr. Carter's point is well taken, and there is no disagreement whatsoever, as one is an experimental installation and modifications must of course be made for large scale commercial testing.

GUSTAF A. GAFFERT.

Liner Wear in Oil Engines

PART OF THE LINER WEAR in oil engines is unavoidable being due to friction etc., it should, however, never exceed 0.001 inch per 1000 hours running. Excessive liner wear may be due to bad fitting of the piston rings so that they bear excessively hard on the liner walls, to inferior cylinder lubrication, to the use of fuel with too great a solid content or frequent starting and stopping.

Cold starting is a cause of liner wear due to defective piston lubrication, engines started in this condition have lubricating oil which is thick and which flows slowly therefore the cylinder lubrication is inefficient until the engine warms up. All fuel oil contains a small percentage of solid matter which cannot be avoided and which is allowed for in fuel oil specifications, the amount permitted by these should never be exceeded. However, an oil filter should be placed in the pipe line just before the supply reaches the engine as the oil is liable to collect scale, dirt, etc., from the main tanks, pipe lines and during transit.

It is necessary to remove badly worn liners and send them to a machine shop for grinding. If the liner is rusted in or held by scale it may not loosen readily and the jacket should be boiled out with a weak solution of hydrochloric acid and water. If this fails to move the liner the jacket should be connected to a steam or hot water supply and the lower end of the liner sealed so that it can be filled with cold water. The hot and cold water should then be turned on, the contraction of the liner and the expansion of the cylinder jacket will usually permit removal.

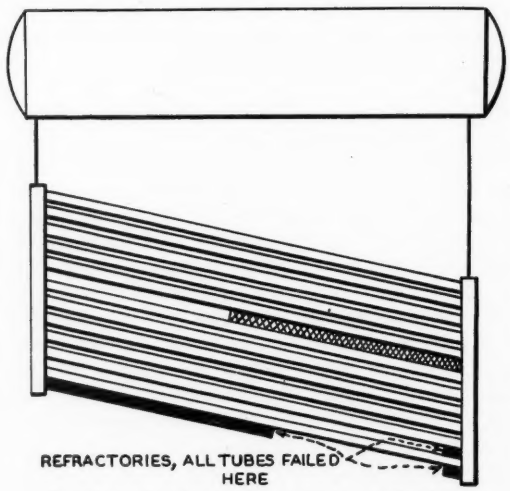
Piston ring grooves are also liable to wear forming shoulders and ridges, preventing the proper movement of the ring and making it difficult when fitting new rings. To a certain extent the formation of ridges is unavoidable, the ring must move freely, this movement causes wear.

Usual cause of the formation of excessively large ridges is badly fitted piston rings, or the forming of slight shoulders harmless in themselves, but if left, wear will continue until large shoulders are formed. When a piston is drawn for overhaul the piston ring grooves should be cleaned with a tooth brush and kerosene and then closely examined for any slight ridges which may be forming. If any uneveness is found it should be lapped away with a narrow flat piece of wood loaded with emery paste. Afterwards the grooves should be polished with a cloth saturated with flake graphite. This will give them a graphite polish which will greatly decrease the friction between the ring and the groove.

Kent, England W. E. WARNER.

Maintenance of Idle Boilers

DETERIORATION of boilers during periods when they are idle is likely to be much more rapid than when in service unless special precaution is taken to guard against corrosion. The method of idle boiler maintenance given in standard textbooks of boiler room practice is as follows: If the boiler is to remain out of service only for two or three months, as for the summer period for heating boilers, it should first be cleaned and overhauled, after which it is filled with water to which is added a sufficient amount of soda ash or of whatever chemical is being employed, then it is closed and a slow fire started until all the air is



Location of points where corrosion took place

driven from inside the boiler when the fire is allowed to die out and the boiler left in that condition. If, on the other hand, the boiler is to remain out of service for considerable time, after the boiler has been cleaned and overhauled, it is left to remain empty of water with all doors, damper, manholes and handholes closed and with a quantity of quick lime both in the drums and in the setting.

With the exception that no lime was used, this was the method followed in a boiler room consisting of two heating boilers, 500 hp. each and operating at 50 lb. pressure. Since the steam requirements were never greater than the capacity of a single boiler, one of the boilers, in alternate periods, was continuously out of service and both were out during the summer. In other words, each boiler was in service for about 5 months per year. The tube replacement was between 30 and 60 per year and this condition prevailed for more than 10 yr.

In diagnosing this condition prior to making the inspection, I was inclined to believe that a large por-

tion of the radiator returns was lost and, the water treatment being inadequate, scale resulted which was responsible for the loss of tubes. I expected to find the boilers heavily scaled, or in the absence of this condition, as a second alternative, to be badly corroded. But I found very little scale and no signs of corrosion and considering that the boilers were operated at moderate loads and low pressure, the problem of tube failure tended to become a mystery.

These boilers are longitudinal drum type with the lower row of tubes surrounded with refractories on the underside and all the tubes of the lower bank are also lagged with refractories at the rear headers, as shown on the sketch. All of the tubes failed at the places where they were embedded in refractories. Examination of the replaced tubes showed that they were all badly rusted on the outside at the place of puncture and many badly rusted all along the point of contact with the refractory. Examination of the refractory indicated the presence of water at some time in the past.

In the light of this evidence there could be no doubt but that the tube failure was caused by the water, and my reconstruction of what took place is as follows: Because of a leaky tube the boiler is taken out of service and in due time the tube is replaced and other repairs are done but since the other boiler is sufficient to carry the load, this one remains out of service for a long time. The tubes having become wet from the leaky tube, at the places where they are lagged, the refractory being soaked with water, the corrosive action will go on as long as the boiler remained out of service, while the other portion of the tube will soon dry out without any corrosive action taking place. The corrosive action of the water might have been enhanced by the formation of any sulphuric or nitric acids. At any rate the loss of tubes was brought about by three conditions: with water as the primary factor and the refractory and idle boiler as the accomplices. Without the refractory to retain the water, corrosion would not have taken place since it did not take place at the other portion of the tube, and if the boiler had been in service the water would have dried out.

Knowing the cause of the trouble, the remedy suggests itself. The procedure followed at this plant at the present time is as follows: If a boiler must be taken out of service during the heating season, all repairs are done promptly and immediately afterwards this boiler is placed in service and either run continuously or only for a few days until any possibility of moisture is eliminated. During the off-heat season, after all repairs have been done, the boiler is filled with water and a fire built until steam is formed when the fire is allowed to go out. The water is emptied several days later and the boiler remains closed and empty during the summer months.

Chicago, Ill. N. T. Pef.

THE ADVANTAGES of the grid controlled mercury arc rectifier for high power service are only beginning to be recognized in this country. In Europe this type of equipment has been developed and used to a high degree and it is used in favor of other methods of supplying direct current. Its reliability, silence, low weight, small demands for attention and above all its high efficiency have almost completely displaced other forms of converting machinery in its favor.

The CO_2 Recorder

UNDER THIS heading on page 369 of the June issue in reviewing my article under the same caption on page 249 of the April issue, Mr. Swain stated that—"All of the above tends to show the futility of relying on CO_2 measurement as a combustion guide instead of finding the excess air." This writer also stated, and we agree, that—"To determine the excess air a good guide is a steam flow-air flow or a gas flow-air flow meter."

The Carnegie professor's statement which was quoted should not cause much concern, as it may readily be inferred from the closing sentence of paragraph two that Mr. Swain believes 30 per cent excess air rather high for natural gas fuel. The following statements may be contrasted with the one made by the professor. "Gas-firing, further, requires less excess air for combustion" (than solid or liquid fuels) "—or none." (Hutton's Heat and Heat-Engines page 58.) In industrial processes, "the atmosphere from gas fires may be kept oxidizing, reducing or neutral." Page 56, "Combustion," a publication of the American Gas Association.

In support of the claim that CO_2 measurement is a good combustion guide we again quote from "Combustion," page 56. "Since air contains a definite percentage of oxygen, there must be some simple relation between the amount of CO_2 in the flue products and the oxygen added by the excess air." Several equations are given for determining the combustion constants for gases. With these constants the volume of excess air present may readily be determined from the percentage of CO_2 present.

Since CO_2 is the determining factor in these formulas it is evident that they are not designed for incomplete combustion. Similarly the steam flow-air flow meter is applicable only to complete combustion, as it is based on the principle that the pounds of air required to produce a given number of B.t.u. is substantially the same regardless of the kind of coal burned. Complete combustion of the fuel is presupposed.

While both methods may be theoretically sound yet errors will occur in practice. Difficulty is often met with in properly setting the steam flow-air flow meter. If the meter is set from analyses made by an orsat one may fall into the same errors that were pointed out by Mr. Swain when considering the CO_2 method. If the meter is set empirically at 19 per cent for natural gas, as suggested by one investigator in this field, the error may assume considerable proportions in some installations, since, according to this same authority, this is not the best percentage obtainable but a normal every day average. If a shift is made to a radically different fuel, such as was encountered by Mr. Swain (see paragraph five of that article) the meter should be reset.

The greatest source of error in the steam flow-air flow meter arises from the presence of moisture or inert gases in the fuel, or when steam is used over the fire. These inert vapors produce a record on the air flow but are not effective in making steam. With the CO_2 method the inert vapors are considered in determining the ultimate CO_2 factor.

One objection to the CO_2 method is that it is sometimes difficult to determine on which side of the combustion equilibrium the fires are. The table in the

April issue was given to illustrate this point. Hence as was suggested in that issue a carbon monoxide recorder should be used or orsat tests made frequently.

This table was based on the assumptions that the ultimate CO_2 value of the gas burned was 12 per cent, and that the CO_2 recorder is substantially correct. Under the assumed conditions, if the recorder is showing 12 per cent there are no unburned gases or oxygen in the flue products. Should the recorder show 10 per cent we might have 18 per cent excess air or 2.5 per cent CO. Or, again, we might have a mixture of CO, O_2 and illuminants. Should the unburned gases reach 2.5 per cent, however, the fuel economy would compare favorably with 30 per cent excess air.

The point we would like to emphasize is that if the CO_2 is to be used as the combustion guide it should be kept as near to the maximum value as practical, when burning natural gas. If a CO_2 recorder can not be made to approach the ultimate value by manipulating the air and the gas the trouble should be located and remedied.

Mr. Swain attributes a variation of 2 per cent in the CO_2 content of flue gases to the "changing analyses of the gas itself." The hydrogen-carbon ratio of natural gases is usually taken as 0.25 to 0.33. So the maximum CO_2 value could not vary more than 0.5 per cent. A change from burning methane with a heating value of 1023 B.t.u. to butane with a heating value of 3271 B.t.u. would cause a change of only 2.3 per cent in the CO_2 content of the flue products. The presence of inert gases in the fuel should be considered. Should a change be made from burning methane to a gas composed of 31.3 per cent butane and the remainder inerts, the CO_2 value would vary less than 1.5 per cent. The two gases last named would have practically the same heating value. It should be borne in mind that gases containing 5 to 8 gal. of gasoline or distillates, like the butane mixture described above, are rarely used as fuel until dried and the gasoline removed. So it is believed that Mr. Swain should seek other causes for the CO_2 variations in his gas analyses.

Before closing we wish to refer briefly to certain items of our boiler room equipment.

Forced draft is used. This means among other things that there is no air infiltration into the boiler settings and that representative samples of the flue products may be secured.

The best of refractories are used in the air cooled furnaces.

We have apparatus for determining CO_2, C_2H_4, O_2, CO, H_2, CH_4, C_2H_6 and N_2. The orsat used in routine testing has four pipettes and tests are made for the four gases first named and N_2. The solutions used are carefully prepared, when not purchased, and when water is used in the measuring burette it is acidulated. If Mr. Swain desires more exact determinations in his gas analyses he should use the Elliot absorption apparatus, as it has some decided advantages over the regular or "Burrel" orsat.

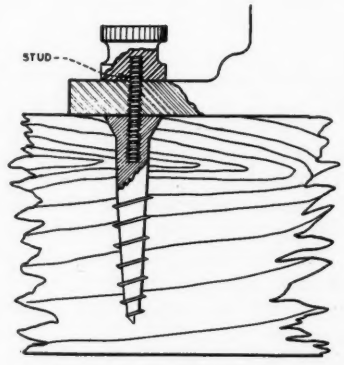
Two types of CO_2 recorders are used—the chemical and the specific gravity types. Many good authorities consider the instruments used as substantially correct and recommend their use as a guide in firing boilers.

Soot blowers are not used. Some time ago we fired a furnace with a reducing flame, endeavoring to keep 2 per cent CO in the flue gases, or enough to absorb all the O_2. No soot was found in the boilers. The presence, however, of butane or higher hydrocarbons in considerable quantities in the gas may cause carbon deposits under similar conditions.

Sugar Grove, Ohio. HENRY COONEY.

Mounting Screw for Wooden Panels

WHERE INSTRUMENTS or gages are mounted on wooden panels and the ordinary wood screws are used to hold them in place, the repeated removal and replacement of the devices causes the stripping of the wood fibre in the holes by the action of the cutting edges of the wood screw. To overcome this it is well worth while where one has this need, to use the scheme shown in the sketch. A large size wood screw is drilled and tapped in the center of its head to take a smaller stud or thumb binding screw as shown. This screw when once turned home makes the wooden panel as good as one of metal for the mounting of instruments.



Improvised mounting screw

Concord, N. H. C. H. WILLEY.

Cutting Painted Metal

IT MIGHT seem a little peculiar that a person could be poisoned in operating the cutting torch. In the case of structural steel and other work that has been painted with a lead-base paint, the fumes from the lead in the paint can easily affect the man using a cutting torch to demolish it. Yet the torch must be used if one expects to make any kind of a showing on the work.

Where there is considerable painted metal to be cut, it will be wise to distribute the work among several cutters, or else take some special precaution to insure the worker against lead fume poisoning. One means of protection is the use of a gas mask. Fitted with a suitable gas mask that covers the nose and mouth, and a suitable pair of welding goggles, the workman will be well protected. Another means of getting rid of the chief part of the lead fumes is to use a sandblaster on the metal to remove the paint, before the torch is applied. The sandblaster, of course, will simply remove bands of the paint encircling the metal at judicious points where it is desired to make the cuts.

Peoria, Ill. JOHN E. HYLER.

New Equipment

De-ion Linestarters

A COMPLETE NEW line of linestarters employing the De-ion principle of arc interruption has been announced by the Westinghouse Electric and Mfg. Co. Designed for across-the-line starting for single phase and polyphase squirrel cage induction motors and as primary switches for wound rotor induction motors, they are especially applicable where push button control is desired with complete protection to the operator, the motor and the machine.

Motor protection is provided by a thermostat disc overload relay. A proper inverse time characteristic prevents shut downs due to temporary overloads. Also, reliable protection is assured against single phase and locked rotor operation. Heaters for operating the disc are interchangeable and easily accessible. The relay can be arranged for either manual or automatic reset.

The arc box is a heavy one-piece, non-carbonizing porcelain section with openings to permit inspection of contacts without stopping production. The De-ion arc quencher confines, divides and extinguishes the arc almost instantaneously and without the usual flash and attendant scattering of the flame. This not only gives unusually high arc rupturing ability but also assures long life of the contacts.

Vertical Lift Fire Door

CORNELL IRON WORKS, of Long Island City, N. Y., have recently developed for large openings a self-closing vertical lift fire door in which the operating speed is under control at all times and which can be instantly reset after an emergency closing. This door was designed for the U. S. Navy for an airplane factory, but is excellently adapted to hangars, motion picture studios, car-building shops or any location where large self-closing doors are used. It has been built to a size of 60 by 20 ft. and can be manufactured to practically any dimensions.

The door section may be of tin-clad wood, structural steel covered with asbestos or any standard fireproof construction. It has very wide lap at lintel and jambs and has tight-closing steel firestops. In operation, the door, partially balanced by a counterweight, slides vertically between guides so designed that no amount of expansion due to heat can cause sticking. The operator consists of one or more oil cylinders with piston rods connected to the door or counterweight and supplied with oil by a motor driven pump. The system is closed and under pressure so that the door cannot close until the valves are properly operated. For emergency closing, the melting of a fusible link opens a release valve permitting the door to close, but holding its closing speed to any desired rate. Resetting this valve restores the door to normal operation. A hand pump is provided for use in case of power failure.

In the Navy Department installation mentioned, a door weighing over 10 tons operated in one minute normally and in 45 seconds for emergency closing. The operator is provided with a cushioning device and the door closes without any shock.

New Tube Visualizes Electrons

MAKING ELECTRONS "VISIBLE" to simplify the study of electronic phenomena is now possible through the use of a new tube developed by engineers of the Westinghouse Lamp Company, Bloomfield, N. J. The new tube has a fluorescent coating on the plate that "illustrates" electron bombardment for demonstration purposes, such as in laboratories, high schools and colleges.

Like the other three-element electronic tubes in fundamental design, the new tube has been especially constructed with a fluorescent coating on the plate. Electrons striking this coating are transformed into visible bands of radiations whose widths depend directly upon the electron beam intensity. Thus, the electrons passing through the grid to the anode form a visible pattern which corresponds to the invisible pattern in a more conventional tube.

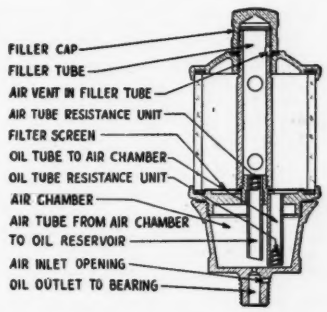
The effects of grid voltage on this transmission are illustrated by changes

produced in the strips of light on the plate. A constant, high negative grid voltage will reduce the bands to fine lines, while a constant positive voltage on the grid will cause the bands to expand to widths sufficient to cover the plate completely. Thus, it is possible to illustrate the fact that a direct relationship exists between the electron flow in a tube and its plate current, namely, that a change in the flow produced by the grid in turn varies the plate current.

In the accompanying picture the value of the new tube as a medium of demonstrating electronic phenomena and their magnetic properties is illustrated when a magnet is held alongside the bulb, distorting the pattern of the flowing electrons.

Oil Cups

ALEMITE, a division of Stewart-Warner Corp., Chicago, Ill., announces two new types of oil cups. Of these two the more unique is the Thermatic Oil Cup. Where a constant, slow flow of oil is desired, it affords reliable and economical bearing protection. There are no moving parts in this cup. Air expansion forces the oil from the bottom of the air chamber, and that supply is replaced from the cup reservoir by gravitational action. An inlet in the base of the cup admits sufficient air to maintain pressure on the oil.



The second new cup,—the Microflow Cup, is particularly adapted to bearings which require a continuous flow of oil in small adjustable quantities. It is fitted with a new device, a resistance unit, which permits a finer adjustment of oil flow and assures positive operation by preventing clogging. The larger opening in the discharge valve assures an unhampered flow of oil and the grooved cylindrical plug, through which the oil must pass to reach the valve, can be adjusted to such a degree that the flow of oil can be made extremely minute, yet constant.

Orifice Meter

THE COCHRANE orifice meter, a new development of the Cochrane Corp., Philadelphia, Pa., is being introduced to meet the wide-felt demand for an accurate, simple and inexpensive instrument to measure the flow of fluids through pipe lines. Flow through the orifice, flow nozzle or venturi tube sets up a differential pressure which is conveyed by piping to the U-tube manometer and measured in terms of rate of flow.

Features include a direct reading integrator, 12 in. diameter charts, spring wound or electric clock for driving charts and integrator, interchangeable manometer tubes to permit altering meter capacity, safeguards in both high and low pressure chambers to prevent loss of mercury, removable cover plate to permit cleaning of chambers, large float with high buoyancy, throttling bushing to dampen violent fluctuations in flow, pressure tight bearing of hardened stainless steel, forged steel float chamber, adaptation to flush panel or rear mounting, pressure and temperature records on same chart with flow, and ranges of meter bodies from 1 in. of water maximum to 200 in.

Air Hose

HIPRESS AIR HOSE, a new product designed for all types of air tool applications, has been announced by The B. F. Goodrich Company, Akron, Ohio.

This hose is unique in that it is a combination construction made in long lengths. The inner carcass consists of four plies of specially woven duck. The outer carcass is a tight braid of high tensile cords which are applied with a tension ten times that normally used on long length braided hose. Between the inner and outer carcass is a substantial insulation which serves as a secondary tube to seal off penetration of air through the walls of the hose and to cushion blows from the outside.

The wrapped construction of the inner carcass provides an ideal backing for the tube due to the fine weave of the fabric. This is particularly valuable when tube is subjected to softening from internal heat. Due to the bias design of the wrapped fabric, any air or fluid which reaches it travels only a short distance before reaching terminal point of the yarn, thus preventing penetration throughout entire length of hose. However, the use of an outer braided carcass gives greater flexibility and more secure adhesion of cover than is obtainable with an all-wrapped construction.

The tube is made of a special rubber capable of resisting both oil and heat. Not only is it claimed that this tube will last longer in air hose service where oil is present but that it will not break into loose particles and clog the tools. The rubber cover of hose is compounded to withstand abrasion and abuse.

Hipress air hose is furnished in three sizes, ½, ¾ and 1 in., and will be made in 500 ft. lengths.

Automatic Pressure Compensator

IN MEASURING the flows of compressible fluids such as steam, air and gas, variations in the static pressure of the flow directly influence the flow reading. To prevent errors from this source, The Foxboro Co., Foxboro, Mass., has developed the Automatic Pressure Compensator for Foxboro Flow Meters.

The Automatic Pressure Compensator mechanism is shown in the illustration. It is merely a simple spiral pressure tube connected to a lever.

As the line pressure changes, the spiral adjusts the multiplication of the linkage between the float and pen arm. This is not an additive correction but a percentage correction; the linear amount of correction differs at different points of the chart and is calibrated to fit the flow formula of the meter.

Thus a continuous, instantaneous and accurate compensation for pressure changes is obtained automatically. The device is sensitive to, and will correct,

the position of the flow pen for a change in pressure as small as one-tenth of 1 per cent.

At zero flow, pressure changes do not affect the position of the flow pen; at all other points on the chart the shift in pen position is just sufficient to compensate for the effect of this factor in the flow formula. On square-root flow scale meters the pen position is varied proportionately to the change in absolute pressure; on uniform flow scale meters, pen position is varied proportionately to the square root of change in absolute pressure.

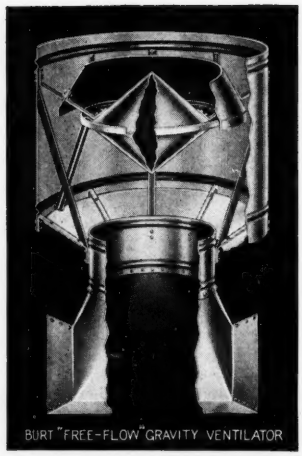
Should maximum flow and maximum pressure occur simultaneously, the pen will not travel beyond the upper chart limit.

If at any time a pressure compensating meter is changed over to a service where compensation is not required, the meter is easily adapted to the new service. By attaching one screw on the compensator to the mounting post in the instrument, the compensator becomes inoperative and the differential calibration is that of a non-compensating meter.

The Automatic Pressure Compensator does not affect the inclusion of pens for recording pressure or temperature.

Gravity Ventilators

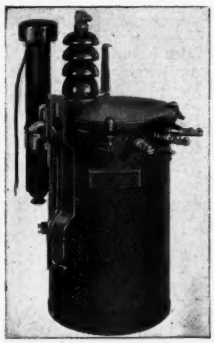
FREE FLOW GRAVITY VENTILATORS of a new design and with exceptionally large capacity are announced by The Burt Manufacturing Co., Akron, O. The new construction differs from the usual type in that a great part of the discharge from the ventilator is vertically upward instead of beneath the windband. All internal louvres have been eliminated. The upper air flow baffle located between the top and windband renders the unit stormproof and prevents back draft without retarding the air flow. The lower air flow baffle prevents discharge of air from beneath the windband, sufficient drain opening being provided between the air-shaft, baffle and windband to allow the free passage of rain, snow or trash which may flow into the ventilator top. This new unit is made in a range of vent sizes from 8 to 96 in., inclusive, giving a range of capacity from 50 to 35,560 c.f.m., depending upon the temperature, stack height and wind velocity. It is made in three models, without a damper, with a butterfly damper or with a louvre damper, and may be obtained in either manual or automatic control.



BURT "FREE-FLOW" GRAVITY VENTILATOR

Distribution Transformers

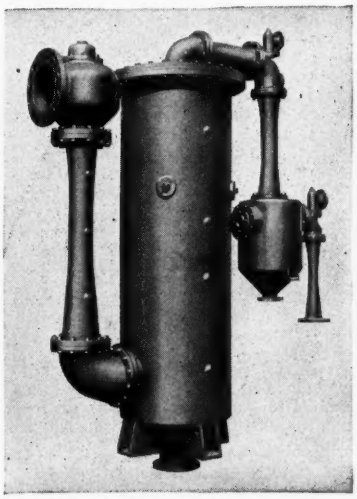
ALLIS-CHALMERS MFG. Co. has just placed on the market a new line of distribution transformers for rural service, built in the various commercial voltages in sizes 1½, to 10 kv-a. inclusive. These transformers are characterized by exceptionally low copper loss and low inherent reactance. The high and low voltage coils are wound separately and are of circular design. The high voltage winding is wound on a sectionalized spool and can easily be slipped off of the helical low voltage winding.



These transformers form an addition to the existing line of rural type transformers manufactured by this company and supplement their conventional lines of distribution types. They can be provided with arrangements for directly bolting to the pole or conventional hanger hooks can be supplied. They are made either with one or two primary bushings and include provision for mounting surge diverters. All primary bushings are coördinated against surge conditions.

Steam-Jet Ejectors

FOR PRODUCING VACUUMS of from a few inches to less than one millimeter of mercury, Worthington Pump & Machinery Corp., Harrison, N. J., is offering steam-jet ejectors in single or multiple units.



Various types of this unit are shown in their application to many industries such as chemical, petroleum, wood-treating and general processing, together with condensers for power generating stations in bulletin W-205-B2.

Crane Control

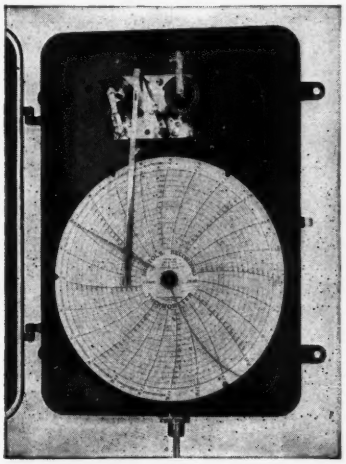
LINK-BELT Co., Chicago, announces a power control, with short, easy-throw levers; to be known as Speed-O-Matic control. The advantages are enumerated as (1) elimination of operator fatigue; (2) much speedier operation; (3) greater output. In principle, a small fraction of the power of the machine is harnessed

for doing the work under the guidance of the operator, instead of requiring his doing manual labor in performing the necessary operations thousands of times a day.

The Speed-O-Matic control is referred to as having literally no wearing parts between the clutches or brakes and the conveniently arranged control stand behind which the operator is comfortably seated, at front of cab. Even the foot pedals are operated from this seated position.

Tube Thermometer

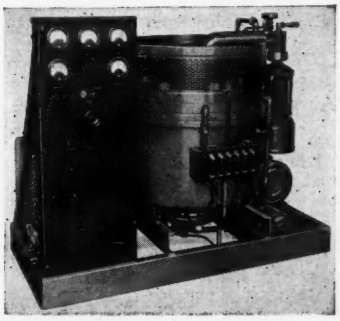
GAS-FILLED RECORDING THERMOMETERS, having a small temperature-sensitive bulb for long lengths of connecting tubing, have been developed by The Bristol Co., Waterbury, Conn. It is offered for measuring temperatures between minus 60 and 1000 deg. F., where tubing lengths as long as 100 ft. and even longer under certain conditions, are required by the application.



Bristol's Small-Bulb Gas-Filled Thermometer is fully compensated, being so designed that temperature changes in the case of the instrument and along the tubing are corrected for, independently, by means of an accurate compensating device. This device eliminates the necessity of long bulbs on thermometers having tubing lengths over 25 ft. They are offered with one or two pens in the 12-in. chart size: and with one pen only in the 8-inch chart size.

Low-Capacity Low-Voltage Rectifiers

ALLIS-CHALMERS MFG. Co., Milwaukee, Wis., has developed a low-capacity, simplified, all factory-assembled, grid-controlled mercury arc rectifier set with a rating of 150 kw. at 250 v. and 300 kw. at 550 v., direct current. This set, has the rectifier tank, all auxiliaries and control panel assembled and wired on a common frame.



The set occupies a floor space of only 3½ by 6 ft., stands about 5 ft. high, and weights approximately 3500 lb.

Due to simplicity of installation and operation, small space requirements, high conversion efficiency, particularly at partial loads, this rectifier is well adapted for power conversion in unattended substations of office buildings, hotels, hospitals, warehouses, etc., in cities where a changeover from d.c. to a.c. network is taking place. This rectifier will also find an application in many industrial plants where a small amount of d.c. power is required for special drives, or processes. It will also find application in d.c. power supply to mine haulage systems.

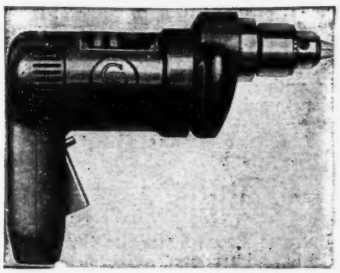
Scale Eliminator

ELEK-TROL-IK is the name given to a boiler scale remover and eliminator announced by Oneida Electric Mfg. Co., Green Bay, Wis. It functions on the principle of creating an electrolytic action

within the boiler to destroy all boiler scale without damage to the boiler plates or tubes. It is designed for use in boilers up to 100 hp. capacity, but in larger boilers more than one is used.

"The Midget" Electric Drill

CHICAGO PNEUMATIC Tool Co., 6 East 44th Street, New York have recently issued a novel catalog describing their new "Midget", newest and smallest universal electric tool for $\frac{1}{16}$ in. drilling. This catalog which



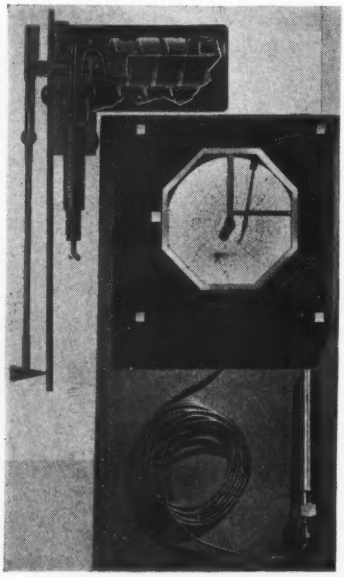
has stiff and cardboard covers is in the shape of the tool itself and is actual size. The tool is shaped like a pistol and is complete with electric motor, trigger switch and chuck. It weighs 2 lb. 10 oz. It can be used for drilling, screw driving or nut running.

New Thermometer

FEATURES incorporated in this new thermometer of Republic Flow Meters Co., Chicago, Ill., are a nitrogen-gas-filled helical coil, capillary tube and sensitive bulb welded together, calibrated and sealed in the laboratory to form a "cartridge sealed" unit. This can readily be removed from the panel for recalibration or repair without disturbing any mechanism and has a micrometer gear adjustment to revolve the helical element on its shaft so as to adjust the zero position of the pen. Movement of the helical coil operates the pen direct, without multiplying devices. The element is held to the panel by two screws, so that releasing these permits removal or replacement. Non-removable chart knob is so attached to the pen lifter that the pen is lifted from the chart when the knob is turned.

Operating ranges are between —20 deg. and +1000 deg. F., the panel being mount-

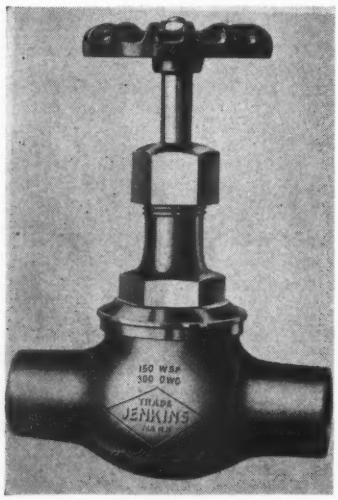
able at any point up to 200 ft. from the point of temperature measurement, with readings compensated for effects of temperature on the capillary tube. This tube may have flexible protective armor of



bronze, steel, lead or brass and nickel alloy as best suited to its surroundings. The 10-in. charts, available for any range, may be driven by electrical or mechanical clocks, sealed dustproof, as is the chart chamber. One, two or three records may be made on a single round chart, or up to six records on a strip chart, of temperatures, pressures and flow. Bulbs may be plain, with rigid extension or bendable extension to suit requirements.

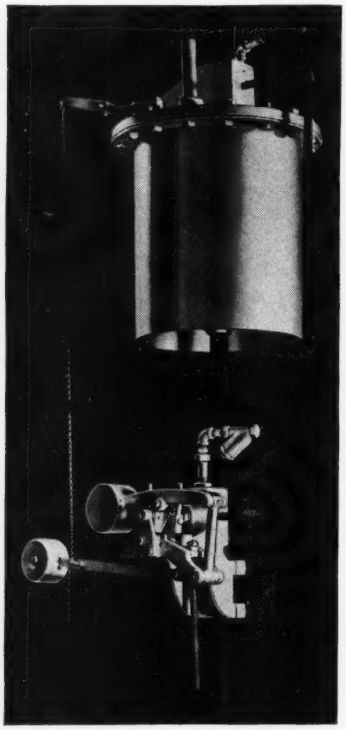
New Jenkins Valves

JENKINS BROS., 80 White Street, New York, have introduced a complete line of solder-end valves for 150 lb. service on copper lines. With the exception of the ends, these new valves are identical with the standard Jenkins valves used for threaded installations.



Boiler Feeder

THE MOREHEAD MANUFACTURING CO., Detroit, Mich., announce the Morehead Midget direct pressure boiler feeder. This unit brings to boilers up to 10 hp. the advantages of return trap practice. Remote control is based on the fact that the tank is independent of the valve mechanism. As a result, the tank may be placed in a



normal operating position above the boiler, while the controlling device remains within easy reach.

The Morehead Midget handles both condensate and makeup water. Completely automatic, this unit requires no further attention once it is installed.

Foam-Making Water Nozzle

AN ENTIRELY NEW method, mechanical rather than chemical, of making foam for fighting flammable liquid fires and suitable for use with long or short lines of ¾ to 2½-in. hose has been announced by the Pyrene Manufacturing Co., Newark, N. J.

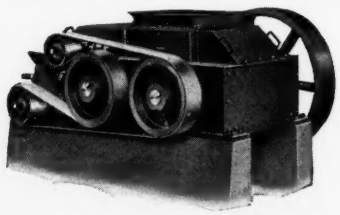
A water stream is converted into a continuous foam stream by coupling a nozzle, known as the Phomaire Play Pipe, to a water line supplying 75 lb. or more pressure at the play pipe. As the water passes through the play pipe, Phomaide—a new foam-making solution—carried by the operator in a hip pack, and air are automatically drawn into the water stream in the proper proportions to form foam.

Water may be pumped from suction, hydrant or water tank. Only about 20 gal. of water per minute are required. One gallon of Phomaide solution makes 350 gal. of foam. Foam production of 300 to 400 gal. per min. may be continued indefinitely by merely pouring additional solution into the hip pack.

In addition to the foam stream for fighting flammable liquid fires a water stream for extinguishing any lingering fire in ordinary combustibles may be discharged by simply lifting the pick-up tube out of the solution. When it is again dropped into the solution a foam stream is produced.

Crusher

THE JEFFREY MFG. CO., Columbus, O., has developed a new design of double roll crusher. The chief feature of this machine is a self-contained endless belt drive between the rolls which allows quick ad-



justment of the rolls within the limits of the sizing range while the machine is running. The crusher is also provided with an all steel frame having heavy steel cross-ties.

Bureau of Mines Reorganized

DR. O. P. HOOD, Chief of the Technologic Branch and Chief Engineer of the Mechanical Division of the United States Bureau of Mines, Department of the Interior, retired on June 30, following 25 yr. of service with the Bureau. Dr. Hood joined the Bureau of Mines at its Pittsburgh Experiment Station in 1911.

Dr. John W. Finch, Director of the Bureau, has announced the appointment of Arno C. Fieldner as Chief of the Technologic Branch of the United States Bureau of Mines, Department of the Interior, to succeed Dr. Hood.

Coincident with the appointment of Mr. Fieldner, the Bureau's Technologic Branch is reorganized. The name of the Mechanical Division is changed to the Coal Division and studies relating to the use of electrical and mechanical equipment in mines are transferred to the Mining Division.

The Experiment Stations Division is discontinued, and the coal preparation section of the Experiment Stations Division and the experimental mine section of the Office of the Chief Mining Engineer are transferred to the Coal Division.

A new division called the Non-Metals Division is created to take over the following technical sections of the discontinued Experiment Stations Division: Fundamentals, Beneficiation, Processing, Utilization and Water.

Mr. Fieldner is a native of Ney, Ohio, and a graduate of Ohio Wesleyan University and Ohio State University. Following some years of chemical and fuel engineering work with commercial companies, Mr. Fieldner entered the service of the U. S. Geological Survey in 1907. On the organization of the Bureau of Mines in 1910, he was placed in charge of the fuel chemical laboratory at the Bureau's Pittsburgh, Pa., experiment station. He was appointed Supervising Chemist of the Pittsburgh Station in 1919 and was made Chief Chemist of the Bureau in 1925. In 1927, he was appointed Chief Engineer of the Experiment Stations Division.

News From the Field

CARL F. WOODS and Geo. F. Felker, President and Vice President respectively for the past 12 yr. of Crosby Steam Gage & Valve Co., have purchased the entire common stock of the company, which insures continuation of the present management under which the company has been eminently successful. During the past few years, the manufacturing facilities of the company have been thoroughly modernized and the growth of the business has required considerable extension of plant which is now under way.

BOETTICHER-KELLOGG Co., Evansville, Ind., has been appointed a jobber of the complete line of tubular products manufactured by Republic Steel Corp., Cleveland.

THE KENNEDY VALVE MFG. Co. of Elmira, N. Y., announces the appointment of Leonard E. Shaffer as Pacific Coast Manager. Mr. Shaffer will be in charge of the Kennedy San Francisco Branch at 448-450 Tenth Street, San Francisco, Calif. He will also continue to maintain his Los Angeles office at 1340 East Sixth Street, Los Angeles, Calif.

AN ATTEMPT will be made to relieve the present chaotic situation with regard to symbols for equations in thermodynamics at an International Conference which has been called by The American Society of Mechanical Engineers, to be held in the Engineering Societies Building, 29 West 39th Street, New York, N. Y., on September 14 and 15, 1936. American usage in regard to such symbols has become fairly well standardized since the publication of the list prepared by the A.S.A. Subcommittee on Symbols for Heat and Thermodynamics. This is now generally adhered to in America, but other lists have been issued by various European bodies.

JOHN J. O'BRIEN, president of H. M. Byllesby and Co. and Standard Gas and Electric Co., died at his residence in Chicago Friday evening, August 7, of a heart attack following a two weeks' illness. Mr. O'Brien, who has been prominent in the public utility industry for many years, was born in Chicago April 2, 1869, the son of James and Bridget (Long) O'Brien. He was educated in public and parochial schools and business colleges and was employed by the Pullman Co. at the age of 18. Two years later, in 1889, he became associated with the Chicago office of the United Edison Manufacturing Co. predecessor of the company which was merged with the General Electric Co. in 1892. He was in charge of accounting for the Chicago office territory of the General Electric Co. when, in 1902, he became associated with the late Colonel H. M. Byllesby in the formation of the Byllesby organization. During the years that followed, Mr. O'Brien served as treasurer and general auditor of the company, and upon the death of Colonel Byllesby in 1924 he was elected president of the Byllesby organization.

As a partner in the Byllesby organization, Mr. O'Brien was a pioneer in the promotion of the group method of developing electric and gas properties, through the application of centralized financial, engineering and management services. He was a director of many utility companies, including the following: Standard Power and Light Corp., Northern States Power Co., Louisville Gas and Electric Co., Oklahoma Gas and Electric Co., Philadelphia Co., Duquesne Light Co., San Diego Consolidated Gas and Electric Co., Southern Colorado Power Co., The California Oregon Power Co., Mountain States Power Co., and Pacific Gas and Electric Co. He was also a member of the board of trustees of Edison Electric Institute.

FISHER GOVERNOR Co., Marshalltown, Iowa, announces the appointment of General Meters & Controls Co., formerly General Instruments and Controls Co., 205 West Wacker Drive, Chicago, Ill., as direct representative who will be engaged in the engineering, sales and service of Fisher controls.

STEPHENS-ADAMSON MFG. Co., Aurora, Ill., has appointed F. E. Dunlap as branch manager in charge of conveyor sales and engineering for the State of Michigan with offices in the Book Tower, Detroit. 9152—1 cut

ALFRED ALSAKER, chief engineer of the Delta-Star Electric Company, died at Long Beach, Long Island, Aug. 3 following injuries received when struck by a motorcycle. Born near Bergen, Norway, Oct. 14, 1884, he was educated there, receiving his Electrical Engineer's degree in 1904 and for a short period was installation engineer for Allgemeine Elektricitats Gesellschaft. Employed by the Commonwealth Edison Co., Chicago, in 1906 and 1907, he transferred to the Public Service Co. of Northern Illinois in 1908, advancing to chief draftsman and then to engineer of station design, resigning in 1916 to affiliate with the Delta-Star Electric Co.

FOR THE PURPOSE of coördinating standardization work being carried on under the American Standards Association in the mechanical field, a Mechanical Standards Committee has been formed and will serve in an advisory capacity to the Standards Council.

Alfred Iddles, vice president of United Engineers and Constructors, Inc., representing the A.S.M.E., is chairman. F. H. Morehead, Walworth Company, representing the Manufacturers' Standardization Society of the Valve and Fittings Industry, is vice chairman. John Gailard, mech. eng., A.S.A. staff, will act as secretary. Other members of the committee are: W. I. Cantley, mech. eng., Lehigh Valley Railroad Co., representing the Association of American Railroads; J. H. Edmonds, gen. mgr., Bethlehem Steel Co., representing the American Institute of Bolt, Nut & Rivet Manufacturers; Frank O. Hoagland, master mechanic, Pratt & Whitney Co., representing the National Machine Tool Builders' Assn.; H. H. Morgan, manager, Rail and Fastenings Dept., Robert W. Hunt Co., representing the A.S.T.M.; Clarence W. Spicer, vice pres., Spicer Manufacturing Co., representing the S.A.E.

CHRISTIAN PAULSEN BERG, Chicago, died on July 4, bringing to a close a career devoted to the establishment of scientific management in shop practice. His experience dated back to the day of Frederick W. Taylor and Carl Barth, with whom he was associated in the early days. Mr. Berg was an outstanding mathematician and an exceedingly capable efficiency engineer. Since 1932 and until his death, which came but four days after leaving his work, Mr. Berg had been in the employ of Link-Belt Co., Chicago, where he did much in recent years, to further systematize routine in both shop and office.

LACLEDE CHRISTY CLAY PRODUCTS Co., St. Louis, announces the appointment of Armin O. Schleiffarth as manager of its flat suspended arch and supported wall division. Mr. Schleiffarth joins the Laclede organization after 8 yr. with the Improved Equipment—Russell Engineering Co., of New York City where he served in the capacity of engineer in charge of construction. Formerly he was connected, for a period of 13 yr., with the Russell Engineering Co. of St. Louis, at that time a subsidiary of the Laclede Christy Clay Products Co.

RESEARCHES on which present national and international steam tables are based to a considerable degree, were honored at the Michigan College of Mining and Technology, Houghton, Aug. 6, through the conferring of the honorary Doctor of Engineering degree on N. S. Osborne, Michigan Tech alumnus and U. S. bureau of standards physicist.

INTERNATIONAL Acetylene Assn. is to hold its 37th annual convention in St. Louis at the Jefferson Hotel Nov. 18 to 20, with technical sessions on welding and cutting of metals by the oxyacetylene process each afternoon and on two evenings.

J. F. LINCOLN, president and general manager of The Lincoln Electric Co., Cleveland, Ohio, on a recent business trip to Germany completed negotiations with the Messer Co. of Frankfort-on-Main for United States representation of a low-priced automatic machine to manufacture oxygen for use in the oxyacetylene process. It is believed that low cost and economy of operation will make this equipment of interest to plants using as low as 500 cu. ft. of oxygen a day. A demonstration plant will soon be installed near Cleveland and be available for observation.

A NEW FIRM, Patton and Bruce, has been formed in St. Louis, Mo., to represent the boiler water conditioning and combustion control interests of the Hagan Corp. of Pittsburgh, Pennsylvania, and its affiliates, Hall Laboratories, Incorporated and The Buromin Company. Members of the firm are Russell Patton and Warren C. Bruce, located at 526 North Vandeventer Avenue. Mr. Patton has long been connected in a sales and service capacity with interests in the power plant equipment field, and Warren C. Bruce, a consulting and research chemist, has recently served the St. Louis City Water Department which he leaves to join Mr. Patton in the firm of Patton and Bruce. With the new firm will be associated W. Scott Wilkie, formerly with S. Thomas Engineering of St. Louis, who for many years represented the Hagan Corporation, Hall Laboratories and The Buromin Company in St. Louis. Mr. Wilkie will continue with the same lines with Patton and Bruce.

WILLIAM GOEDECKE, sales engineer attached to the New York office of Robins Conveying Belt Co. whose death occurred on August 15 had been with the company for over 20 yr. In the early days he was engaged in engineering work and contributed many ideas to the art of modern material handling. In his recent years he was in sales work covering the eastern part of the country. Mr. Goedecke died at fifty-four years of age and is survived by a wife and daughter whose home is in West Brighton, Staten Island.

For the Engineer's Library

How to Build Up Furnace Efficiency. By Jos. W. Hays. Published by the Dunes Publishing Co., Michigan City, Ind. Size 5½ by 7½ in., 538 pp., cloth bound. Price $3.

The wide appeal of this book is shown best by the fact that this is the eighteenth edition since 1908 and the sales have run up to over 125,000 copies. The purpose of the book is to explain the essential facts of combustion efficiency in simple, entertaining, easy-to-understand language and to make it interesting and profitable to everyone who has anything to do with the burning or selling of coal, oil or gas. It is well illustrated, many times with humorous cartoons, intended to impress essential facts upon the reader. The sole effort has been to show the manager, superintendent, engineer and fireman how they may proceed at once actually to work a real reduction in fuel bills and how this may be done without knowing or caring what the atomic weight of carbon may be or why one atom of carbon unites with two of oxygen to form the gas CO_2. This does not mean that the fireman should not know these technical details but the first consideration is to acquaint him thoroughly with the job before him, that is burning the fuel with the greatest possible efficiency.

Corrosion Resistance of Metals and Alloys. By Robert J. McKay and Robert Worthington. First Edition. Size 6 by 9 in., cloth, 492 pages, illustrated. Published by Reinhold Publishing Corp, 330 W. 42nd St., New York, N. Y. 1936. Price $7.00.

By arrangement with the Interallied Conference of Pure and Applied Chemistry which met in London and Brussels in 1919, the American Chemical Society was to undertake the production and publication of Scientific and Technologic Monographs on chemical subjects. This book is one of these monographs.

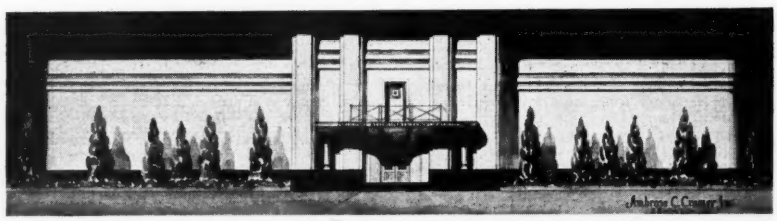
Its purpose, as stated by the authors, is to summarize the facts on corrosion process and rates. In a subject so complex as corrosion, it is inevitable that statements on the facts of corrosion rates will find some disagreement on the part of manufacturers and possible users who hope for better resistance properties. While it is often possible to soften bald statements of such a necessarily unpleasant and negative action as the corrosion of a metal, the authors believe that a more useful purpose is served by a fair statement of facts as can be given and this is the course they have pursued in this book. The data given mostly cover the facts only; they offer no panacea for corrosion difficulties. In the present state of knowledge of non-ferrous alloy corrosion, it is not possible to give any general methods of prevention. The cure in most cases is to use the right alloy in the right place. The data presented in this book will aid one in selecting the right alloy. Data from experience and test on the action of alloys under given conditions form the main or second part of the book. The first part, comprising only 95 out of the total of 492 pages, attempts to classify and explain the economically important points of the theory or mechanism of corrosion. Combination of data from Part II with the general facts of Part I should enable the reader to reason for himself on corrosion problems on which direct data are not available.

It is an excellent, very practical book.

American Electricians' Handbook. By Terrell Croft. 4th Edition, revised by Clifford C. Carr. Size 4x6½, fabricoid binding, 1052 p. Illustrated. Published by the McGraw-Hill Book Co., Inc., New York, 1936. Price $4.

This handbook needs no introduction to those engaged in practical work in the electrical field. For many years this has been the standard source of reference for the practical electrician, and the electrical engineer also has found it invaluable. It always has been and remains a practical man's handbook. The aim has been to collect such information as will enable practical electrical men, wire men, contractors, linemen, small plant superintendents, operators and construction engineers to select and install commercial apparatus and materials intelligently for the performance of given services, and to qualify them for operating the equipment after it has been installed. This edition is not greatly different from the third edition published in 1932. In 1931 because of the many important developments in electrical equipment and in the methods of install-

Windowless Building for National Aluminate Corporation



The National Aluminate Corp. has plans under way for the construction of a windowless building to house its industrial research laboratories and offices at 6221 W. 66th Place, Chicago, Ill. Plans have been prepared under the direction of Ambrose C. Cramer, Inc., 820 Tower Court, Chicago, for a two story building 135 by 100 ft., to be constructed of white terra cotta with bands and decorative entrance feature. The air conditioning system was designed by Robert E. Natti.

This windowless office building was developed to satisfy highly scientific requirements of perfect interior weather conditions at all times and to furnish a constant scientifically predetermined illumination. The building consists of private offices, general offices, general and special laboratories, recreation room, cafeteria and other essential requirements.

Conditioned air will be supplied to each room all year round, furnishing six complete air changes per hour and one complete fresh air change every half hour —conventional office buildings in winter have a complete fresh air change in one to two weeks only. In winter a constant relative humidity will be maintained. Each room has heating and cooling thermostats maintaining temperatures as desired by the occupants. All the air circulated is cleaned by automatic filters in all seasons. Regardless of outside weather conditions, each space can be maintained at the comfortable condition desired by each occupant. The air is cleaned, humidified or de-humidified, heated or cooled and forced by a system of fans through air ducts, grilles and accessory equipment, insuring a circulation at the rate of 30,000 cu. ft. per min.

Each room is equipped with a wall type electric clock operating on the lighting system. At each corridor wing is a weather indicator supplying the need for knowing at all times what the outside weather conditions are by means of a small panel having three colored glass bull's-eyes and miniature electric bulbs behind each.

All illumination is of the indirect or indirect-direct type, combining Mazda or incandescent lamps with mercury vapor lamps, to provide a light having the quality of outdoor daylight. Intensities of lighting will vary from 20 to 70 foot-candles, depending upon necessities of individual use.

All rooms will have acoustical ceiling treatment, with rubber tile floors and walls covered with wall type linoleum, thus furnishing quiet working conditions, with no distraction or annoyance from outside noise sources.

The principal product of the National Aluminate Corp. is in the field of chemicals for treatment of water. One of the main features of the building therefore is a general laboratory, 56 by 43 ft., the walls entirely treated with structural glass in white, with green and black glass decorative effects in the modern manner, with special laboratories grouped about the general laboratory. A separate display room will accommodate four miniature boilers which duplicate large high pressure railroad and industrial equipment of this nature.

It is interesting to note that, with a windowless type of construction, an economy of approximately 20 per cent in building cost is effected as compared with the conventional type of office building with windows. Due to complete insulation and with no heat or cold loss through windows, very substantial savings in heating and cooling are effected. Were it not for the necessity of admitting fresh air to the air conditioning system, winter heating at 10 deg. below zero could be accomplished solely by the heat supplied by illumination, an interesting commentary on such an enclosed and insulated building. Another feature will be the complete absence of dust or necessity of redecorating presumably only every 10 yr.

ing material wire as well as because of the radical changes in the National Electrical Code, a revision of the book became necessary. At this time each of the six divisions was revised and more than 200 pages of new material were added to the volume. This resulted in the 1932 edition. Now, the changes in the 1935 edition of the National Electrical Code have necessitated another revision and this fourth edition brings the book into complete accord with the 1935 Code.

THE ELECTRIC EYE—IN THEORY AND PRACTICE. Published by Hugh H. Eby, Inc., 2066 Hunting Park Ave., Philadelphia. Size 8½x10½ in., planographed, 32 pp., paper bound. Price 50c.

For those interested in the innumerable industrial applications of the electric eye, this booklet will prove to be a storehouse of practical information and a revelation of the simplicity and ruggedness of the equipment.

Various types of photo cells are covered briefly but the main body of the book deals with the characteristics and applications of the conductive type of cell in which the resistance varies with the amount of light falling upon it. Fundamentally the application of the cell circuits is based on the Wheatstone bridge principle and it is used in connection with regular vacuum type amplifiers of the triode or pentode type. Many practical circuits are shown with the constants included and a few of the many uses to which these cells have been put are listed in the back of the book as a suggestion.

WATER PURIFICATION CONTROL, by Edward S. Hopkins. 5½ by 8½ in., 184 pages. Published by The Williams & Wilkins Co., Baltimore, Md., 1936. Price $1.75.

Being the principal sanitary chemist of the Bureau of Water Supply, Baltimore, Md., Edward S. Hopkins has had an opportunity to delve deeply into the subject of pure water for public use and in this second edition of his book he deals with coagulation process, sedimentation, filtration, disinfection, tastes and odors, corrective treatment, plant control data and closes with a chapter on softening. The book is conceived as an aid to men in charge of water purification plants and is written in the language of the practical man rather than that of the theorist.

TECHNICAL DRAWING, by Frederick E. Giesecke, Alva Mitchell and Henry C. Spencer. 6 by 9 in., 564 pages, 1936. Published by The Macmillan Co., New York City. Price $3.

The authors of this book are connected with the Agricultural and Mechanical College of Texas and have made an extremely fine contribution to engineering literature in presenting a class book and reference book in technical drawing. While the volume is not intended as a manual from which drawings are to be copied step by step, it is a comprehensive treatment of the science of technical drawing, arranged logically and contains a large group of practical problems which afford a highly flexible aid to the teacher in the development of the subject and will prove an invaluable reference book to engineers engaged in drafting. There are 19 chapters in this book besides an appendix, each one of which is a comprehensive treatment of the subject under discussion. Particularly impressive are the treatment on instruments and materials, lettering, pictorial drawing and reproduction of drawings, all of which bring to the reader the latest ideas on equipment and methods used in the present day drafting room.

GRAPHIC SOLUTIONS, by Chas. O. Mackey, published by John Wiley & Sons, Inc., New York, 1936. Size 6 by 9 in., 130 pages, price $2.50.

The author of this book is assistant professor of heat power engineering, Cornell University, and has prepared this book as a treatise on graphic computations. The text contains the material believed to be sufficient for a well rounded course. The treatment is elementary and the mathematics simple, requiring, however, a working knowledge of logarithms, algebra and plane geometry. The book contains chapters on stationary adjacent scales, sliding scales, on the nature of intersection charts, alinement charts and imperical equations—non-periodic curves.

AN ANALYTIC STUDY OF THE CHARGING CHARACTERISTICS OF MARX SURGE GENERATOR CIRCUITS. By C. S. Roys. A Bulletin (No. 50) of the Engineering Experiment Station of Purdue University, Lafayette, Ind.

A highly mathematical analysis of the electrical characteristics of the Marx type impulse generator which is a circuit composed of combinations of condensers, resistances and spark gaps supplied with high voltage current through a rectifier. The substance of the material contained in the book was part of a dissertation submitted towards the degree of Doctor of Philosophy in June, 1933.

SYMPOSIUM ON PEARLITIC MALLEABLE CAST IRON was the subject of a meeting sponsored by the Cleveland District Committee of the A.S.T.M. and the report has been printed as a 32 p. paper bound pamphlet. It is available from the headquarters of the Society, 260 South Broad St., Philadelphia, at 60 cents per copy. The symposium is divided into three general parts: Introduction, producers data and patents, with the last 6 p. devoted to discussion.

CATALOG H, covering ammonia valves and fittings, is a 36 page booklet in color just issued by Frick Co., Waynesboro, Pa. In this edition an innovation has been made and prices on the various fittings are given separately and also complete with companion flanges, bolts and gaskets. Many new items appear such as electric control valves, liquid level indicators, diffusers, bolts and nuts, gaskets, pipe hanger fittings and a complete list of repair parts for ammonia valves.

COMBUSTION ENGINEERING CO., 200 Madison Avenue, New York, N. Y., has just issued a catalog describing its CE-Skelly Stoker Unit—a stoker of advanced design for burning all grades of bituminous coal and applicable to all types of boilers in sizes ranging from small heating units to power boilers up to 400 hp. It is available with either electric or steam drive in three types, namely, center retort, moving grate; side retort, moving grate; and side retort, stationary grate. Drawings of application to various types of boilers and furnaces are appended.

STEAM ENGINES FOR THE REFINERY is the title of bulletin S-575-B1 just issued by the Worthington Pump & Machinery Corp., Harrison, N. J. Other recent bulletins include W-310-B5, pressed steel frame centrifugal pumps; W-101-B3A, horizontal duplex piston pumps, and W-101-B4B, horizontal duplex piston pumps, Type VD.

WHITING CORP., Harvey, Ill., has recently published its Bulletin No. 300 dealing with Whiting Tiger Cranes. The bulletin is profusely illustrated with views of installed equipment and details of parts of the cranes, which help greatly in the description given of the company's product.

KELLOGG MASTERFLEX PIPING is the title of a bulletin recently issued by The M. W. Kellogg Co., 225 Broadway, New York, N. Y., describing this type of piping, which is designed for high pressures and temperatures giving maximum flexibility, strength and compactness.

COCHRANE CORP., Philadelphia, Pa., has issued its Publication 2096, describing Cochrane Electric Flow Meters for remote measurement of steam, water, gas and other fluids. It describes in detail the highly accurate galvanometer null principle of measurement and includes description of the styles available for different applications of fluid flow measurement.

SPEED-O-MATIC Shovel dragline-crane is announced in folder 1569 sent out by Link-Belt Co., Chicago, Ill.

GOULDS PUMPS, INC., Seneca Falls, N. Y., is distributing a new bulletin dealing with the company's Hydroil centrifugal purifier. The bulletin, designated as No. 503, covers the application of purifiers for insulating oil when used in connection with transformer, circuit breakers, switches and the like and is of particular interest to the utility and power plant fields.

ILG ELECTRIC VENTILATING CO., Chicago, Ill., has recently issued a new fan and blower catalog designated as BF-45 which covers in a comprehensive way the subject of fans and blowers for use in industry, offices and homes. The catalog contains a great amount of engineering information and many tables of capacities, speeds and power requirements of equipment described in it.

THE ALLEN MFG. CO., Hartford, Conn., has issued an interesting catalog dealing with Allen hollow screws. These screws have many applications in machinery in factories and power plants, and their use is thoroughly described in the new catalog.

CO_2 METERS as built by the Republic Flow Meters Co., 2240 Diversey Parkway, Chicago, Ill., are described in Data Book No. 403. Advantages of CO_2 measurements, methods of meter installation, different types of recorders and indicators and combinations with other instruments are shown.

FAIRBANKS, MORSE & CO., 900 South Wabash avenue, Chicago, in a new bulletin describes in detail the operation and construction of the Fairbanks-Morse Model 32-E Diesel engine. Working features and the functions of the various parts are made clear through the use of many drawings and sectional views.

JOHNS-MANVILLE, 22 E. 40th St., New York City, has recently published a revised edition of its 68-page insulation booklet "Barriers to Industrial Waste." An unusually complete table of recommendations suggests the proper insulations to meet a wide variety of industrial requirements. It also describes Rock Cork Pipe Covering, a new mineral insulation for low temperature piping.

WORTHINGTON PUMP & MACH. CORP., Harrison, N. J., recently issued bulletins covering Type DE Centrifugal pumps; Type TB Horizontal duplex piston pumps; Type DF horizontal duplex direct-acting fire pumps; and Type AE and AF horizontal simplex air and steam heating vacuum pumps.

Power Plant Construction News

Ala., Birmingham — Tennessee Coal, Iron & Railroad Co. plans extensions and improvements in steam power plant at No. 2 works, Fairfield, near Birmingham, with installation of additional equipment. Project will be carried out in conjunction with expansion and modernization of coke plant at that location, including installation of new oven units and other equipment. Entire program will cost over $1,500,000 and will be placed under way in fall. J. L. Perry is president.

Ark., El Dorado—Lion Oil Refining Co. plans installation of power equipment, pumping machinery and other mechanical equipment in new addition to lubricating oil works, to develop large increase in present output. Bids on different features of project will be received in September. Cost about $140,000. J. J. Allison & Associates, El Dorado, are engineers.

Calif., San Francisco—General Brewing Corporation, 2601 Newhall Avenue, plans installation of power equipment in new additions to brewing plant. Entire project will cost about $225,000. Fred H. Meyer, Kohl Building, is architect. Work will begin at early date.

Conn., Rockville—M. T. Stevens & Sons Co, North Andover, Mass., plans installation of electric power equipment in new two-story dye house at branch textile mills at Rockville, 50x180 ft. Cost close to $75,000. Superstructure will begin at early date.

Fla., Dade City—Pasco Packing Association, Dade City, plans installation of power equipment, mechanical-handling apparatus and other equipment in proposed new one-story citrus fruit-packing plant. Entire project will cost about $70,000. L. C. Edwards is head.

Ind., Indianapolis—International Harvester Co., 606 South Michigan Avenue, Chicago, Ill., plans installation of electric power equipment in proposed new branch plant on West Washington Street, Indianapolis, totaling about 100,000 sq. ft. floor space. Entire project will cost over $125,000. Company engineering department, first noted address, is in charge.

Ind., Portland—Board of Public Works will take bids soon for extension and improvements in municipal electric power plant, including purchase of new 3500-kw. turbo-generator unit and auxiliary equipment. Total fund of $192,000 has been arranged through Federal financing. Bevington-Williams, Inc., Indiana Pythian Building, Indianapolis, Ind., is consulting engineer.

Kan., Wellington — Department of Public Utilities, E. W. Merrifield, superintendent, has plans maturing for extensions and improvements in municipal light and power plant, to include installation of new turbo-generator unit and accessory equipment. Cost about $125,000. Black & Veatch, 4706 Broadway, Kansas City, Mo., are consulting engineers.

Mich., Midland—City Council has approved plans for extensions and improvements in municipal waterworks station, including installation of new motor-driven pumping units and accessory-equipment. Cost about $85,000. City engineering department is in charge.

Mich., Muskegon—Muskegon Motor Specialties Co. plans installation of electric power equipment in one-story addition to automobile crank and cam shaft manufacturing plant. Cost about $40,000. Benjamin McLaughlin, Grand Rapids, Mich., is architect.

Minn., Hopkins—Village Council is arranging financing through Federal aid in amount of $217,500 for new municipal electric power plant, including Diesel engine-generating units and accessories. Work will be placed in progress as soon as fund has been secured. Power Engineering Co., Metropolitan Life Building, Minneapolis, Minn., is consulting engineer.

Mo., St. Louis—Griesedieck Brothers Brewery Co., 1920 Shenandoah Avenue, plans installation of power equipment, mechanical-handling and other equipment in two new additions to brewery, four-story and two-story, 60x60 ft. and 90x100 ft., respectively. Cost over $125,000. Work will be placed under way soon. Janssen & Janssen, Chemical Building, St. Louis, are architects.

N. J., Plainfield—Condenser Corporation of America, 257 Cornelison Avenue, Jersey City, N. J., and its affiliated interest, Cornell-Dubilier Corporation, 4401 Bronx Boulevard, Bronx, New York, manufacturers of radio condensers, etc., plan installation of electric power equipment in new plant at South Plainfield, where former factory of Spicer Mfg. Co. has been acquired. It consists of a group of 24 buildings, which will be remodeled and equipped. Present works will be removed to new location and large increased capacity arranged.

N. Y., Carthage — National Paper Products Co. plans installation of electric power equipment in new addition to tissue paper products mill, 225x235 ft. Entire project will cost close to $200,000. G. E. Emigh is superintendent at plant.

N. Y., Tottenville (S. I.)—S. S. White Dental Mfg. Co., 211 South Twelfth Street, Philadelphia, Pa., plans installation of electric power equipment in four-story addition to manufacturing works at Princes Bay, Tottenville. Superstructure will begin soon. Entire project will cost close to $100,000.

Ohio, Dayton—Standard Register Co., Campbell Street, plans installation of electric power equipment in new addition to manifolding register manufacturing plant. Cost over $100,000. Austin Co., 16112 Euclid Avenue, Cleveland, Ohio, is engineer.

Ohio, East Liverpool—City Council has authorized legislation for proposed municipal electric power plant and distributing lines, including bond, to be ratified by voters at forthcoming November general election. Plant will cost about $1,500,000, of which $825,000 will be provided by bond issue and remainder of $675,000 secured through Federal aid.

Ohio, Fremont—S. E. Hyman Co. plans installation of electric power equipment in new two-story addition to automobile fabric plant, totaling about 18,000 sq. ft., additional floor space. Entire project is estimated to cost close to $30,000, with machinery.

Ore., Eugene—State Board of Control, Capitol Building, Salem, Ore., has rejected bids recently received for addition to power plant at University of Oregon, Eugene, including improvements in present unit, and will ask new bids on revised plans at early date. Cost estimated over $65,000, with equipment.

Pa., Myerstown—Common Council has plans maturing for new municipal electric light and power plant, including distributing lines. Cost estimated at $152,700, of which $68,700 will be secured through Federal aid. Work is scheduled to begin soon.

S. D., Plankinton—State Department of Education has approved plans for new steam power plant at state training school at Plankinton, for which a fund of $67,200 has been arranged, part of which will be secured through Federal grant. Installation will include two 100-hp. boiler units with accessories, and other power station equipment. Work scheduled to begin soon. Walter J. Dixon, Woelfel Building, Mitchell, S. D., is architect; Charles A. Trimmer, State House, Pierre, S. D., is state engineer.

Texas, Georgetown—Common Council has plans maturing for extensions and improvements in municipal electric power plant, including installation of new Diesel engine-generating set and accessory equipment. Bond issue of $60,000 has been authorized. Burns & McDonnell Engineering Co., 107 West Linwood Boulevard, Kansas City, Mo., is consulting engineer.

Texas, Houston—Shell Petroleum Corporation, Shell Building, St. Louis, Mo., plans installation of power equipment, pumping machinery, steel tanks and other mechanical equipment in new addition to oil refinery at Houston. Entire project will cost about $1,500,000. Arthur G. McKee & Co., 2422 Euclid Avenue, Cleveland, Ohio, are consulting engineers.

Wash., Seattle—Milwaukee Sausage Co., 808 Twentieth Street, plans installation of electric power equipment in new one-story meat processing and packing plant on Fourth Avenue South. Entire project will cost close to $65,000. W. C. Jackson is company architect.

W. Va., Nitro—Viscose Co., 200 Madison Avenue, New York, N. Y., manufacturer of viscose rayon products, plans installation of electric power equipment in new addition to mill at Nitro, for which superstructure will soon begin. Entire project to cost in excess of $100,000.

Wis., Center Valley—Outagamie Producers Co-operative Association, Center Valley, care of Klingler & Becker, Amery, Wis., architects, plans installation of electric power equipment in new two-story milk and dairy products plant. Entire project will cost close to $75,000. Architects noted are in charge.

Wyo., Casper—Bureau of Reclamation, Denver, Colo., will receive bids until Sept. 14 for two vertical shaft, 15,000-hp. hydraulic turbines; for two governors with pumping machinery for regulating speed of hydraulic turbines; and for two vertical shaft, 12,000 kva. electric generators, with accessories, for installation in Seminoe power plant, Casper-Alcova Project, Wyo. Installation of equipment will be made by Government (Specifications 691).